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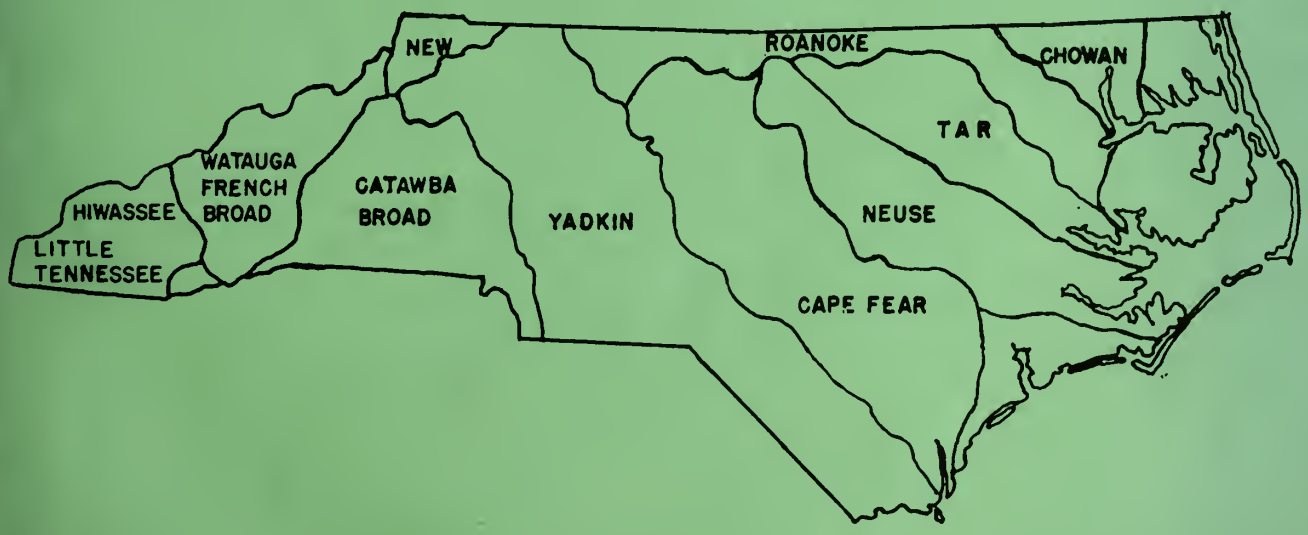

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FOREWORD

An inventory of water resources of North Carolina was authorized, and funds therefor were allocated by the Council of State, on October 11, 1954 upon recommendation, approved by the Governor, of the Advisory Water Resources Committee. This committee was established by the Governor, pursuant to a resolution adopted by the Board of Conservation and Development at their meeting in Raleigh in January 1954, calling for an up-to-date Water Code for the State, and for the conservation and wiser utilization of North Carolina's water resources, and also calling on the Governor to appoint an advisory water committee of seven men to work with the Board's Committee on Water Resources in formulating such a program as called for in the resolution.

The inventory will consist of eleven volumes, of which Volume I herewith will cover water resources of the State as a whole and Volumes II - XI, inclusive, will contain detailed information and data pertaining to the Cape Fear, Neuse, Tar-Pamlico, Chowan, Roanoke, Yadkin, Catawba-Broad, Hiwassee-Little Tennessee, Watauga-French Broad, and New River Basins.

Chapters of each of the eleven volumes will contain information regarding regional characteristics, shortages of water, uses of water, quality of water, stream flow, abatement of stream pollution, soil conservation, watershed management, navigation, flood control, and other subjects as may be appropriate. The last two chapters of each of the eleven volumes will consist of conclusions reached from analysis of the information contained in the preceding chapters, and recommendations as to what should be done in view of those conclusions.

It is believed that Volume I will serve the following purposes: (1) information to legislators and others who may desire it in connection with consideration of proposed water legislation, (2) information which may be used in connection with an educational program regarding proposed water legislation, and (3) advice and assistance to farmers in connection with soil conservation programs and use of irrigation equipment. It is further believed that Volumes II - XI, inclusive, when published, will be of great assistance to the agency which will administer new water legislation, if and when enacted.

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Grateful appreciation is hereby extended to the authors of many publications, the material of which has been used in the preparation of Volume I. A large number of these publications are listed below. It is regretted that a complete list was not made as the preparation of drafts of Volume I progressed. Available time for completion of the work on that part of the inventory included herein did not permit references by appropriate foot-notes to use of material.

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CHAPTER I - - REGIONAL CHARACTERISTICS

Importance of Water - - Next to the air we breathe, water is the most essential material we use. It directly sustains all plant and animal life and is hardly less important in many other uses. Water is the most efficient medium for the transfer of heat and energy, and is universally used as a solvent and cleanser. In the stream-channel phase of the hydrologic cycle, water provides the cheapest transportation of bulk commodities as well as a vehicle for the disposition of most man-made wastes.

The unique properties of water which permit changes from a liquid to a vapor or solid, or vice versa, are being constantly utilized to promote man's comfort and well being. The importance of water in our present-day economy has increased greatly and is continuing to so increase, and, as the demand approaches the maximum available supply, water may become one of our most critical materials. With our constantly rising standard of living and the increasing per capita consumption of raw materials, we may expect the nation's water requirements to double by 1975. In fact, water supply may become the most important factor affecting industrial location.

Water is one of the most important natural resources of a state. The quantity and quality of available water may be the dominant factor in establishment and expansion of industries. Adequate and reliable information about its quantity and quality is necessary as the basis for sound economic development. Water is also important in irrigation for domestic use, and for recreational purposes.

The elementary things which underwrite human life are air, sunshine, soil, and water. The first two elements are beyond man's control. The latter two elements are affected by what man may do with them and to them. The soil and water resources of a nation or of a state are its real wealth. Squandering or mishandling these resources can bankrupt a civilization. Soil in itself without water is unproductive. Deserts having soil rich in plant foods are unproductive because of lack of water.

Life depends on water, which forms seventy per cent of the human body. Every day each person loses at least a pint and a half of water through perspiration whether he or she knows it or not. An athlete exercising strenuously or a ditch digger under a hot August sun may lose, mostly by perspiring, as much as ten pints of water in about one hour. Body organs of an average adult will eliminate from two to five pints of water per day under average conditions. As this water is lost, it must be replaced in order that a person may survive.

Part of the replacement of water that the body loses is supplied in food entering the body, such as cream on breakfast food, moist spinach, or a slice of palatable bread. In addition to water supplied in food there will be a need for water intake each day of four or more glasses of water or the equivalent in coffee, milk, or other beverages.

What the body needs is the most fundamental, but the least in volume, of human demands on water. Some of these demands include brushing the teeth, shaving, washing dishes, washing and rinsing clothes, sprinkling lawns, washing automobiles, washing air in air-conditioning systems, extinguishing fires, cleaning streets, and agricultural and dairying operations.

Regional Characteristics - - The people of North Carolina are asking elementary questions regarding water resources which relate to observable facts of the physical universe which puzzle many of the people. Since it is generally recognized that the average annual supply of water in North Carolina is abundant, they want to know why do some streams continue to discharge generous flows of water year after year without fail, and others, with much larger drainage areas, become dry for extended periods each year; and why is it easier to locate ample quantities of water in the ground in one place and not in another.

The answers to such questions do not have so much to do with water itself, as with the environment in which it occurs. Each region has its own characteristics of geology, topography, and climate. Collectively, they determine whether water will be plentiful or scarce. Without some fundamental knowledge of these elements of a region, it is impossible to understand the variations in the quantities of water that are available from place to place and season to season.

One may notice that streams are slow and placid in one area and swift and turbulent in another, or that the landscape in one region is covered with luxuriant vegetation and in another it is a barren desert. These conditions are the reflection of regional characteristics. In this respect North Carolina is different from other states, and parts of North Carolina differ from each other.

It is the regional characteristics of North Carolina that determine the quantity and distribution of its water resources. These characteristics, when understood, assist greatly in making sound interpretations of the mass of factual data on precipitation, stream flow, and ground water that have been collected over the years. These characteristics include geology, topography, climate, temperature, precipitation, and evaporation.

Geology - - The character of the earth materials and geologic processes not only affect the topographic conditions of a region but are also factors affecting natural drainage, run-off characteristics, and the storage of ground water. The presence of ground water is almost entirely dependent upon favorable geologic formations.

There is a very close relationship between the geology of an area and the quantity and quality of water that can be obtained from wells in the area. Therefore, an understanding of the fundamentals of geology and the principles of the occurrence of ground water are of great value in estimating the ground water possibilities of a locality and in choosing the best possible locations for drilling.

The principal source of ground water is precipitation as rain or snow. The water can enter and move through the soil and unconsolidated rocks only through the openings between the sand grains and clay particles. Entrance and movement through consolidated rocks occur only through the fractures and joints of those rocks. Ground water moves because of gravity, and the point of discharge is always at a lower level than the point of recharge. In North Carolina, recharge occurs in areas between streams, and the natural discharge is into streams, valleys, lakes, and swamps, and into the ocean. Rain falling on the surface enters the openings indicated above and passes vertically downward through the earth until it reaches the zone of saturation, below which the pores and openings of the rock are completely filled with water. The upper surface of the zone of saturation is called the water table, and, in North Carolina, is generally from a few feet to about 600 feet below the land surface. Discharge of ground water is a continuous process so that the ground-water levels are receding except during and immediately

following a period of rainfall, at which time the ground-water supplies are replenished. For these reasons the water table is not a fixed surface but is continually fluctuating.

The amount of water in an aquifer, or water-bearing rock, depends upon the porosity of the rock. Porosity is defined as that percentage of the total volume of the rock that is occupied by pores or other openings. Natural rock materials differ greatly in porosity. The porosity of unconsolidated materials such as sand, clay, and gravel commonly is from 25 to 50 per cent. The porosity of consolidated rocks is much less and is mainly in the joints, fractures, and solution channels.

A rock may have a large porosity and yet yield little water even though allowed to drain for a long time. A clay, for example, with a porosity of 50 per cent, might not yield any water because of the smallness of the pores, the water being retained because of molecular attraction. The ratio of the volume of water a saturated rock will yield by gravity to the total volume of rock is called the specific yield and is stated as a percentage.

Porosity and specific yield are important properties of an aquifer, but permeability, the rate at which water can be transmitted, is the most important characteristic. The permeability of an aquifer depends upon the size and arrangement of the pores. In clays, the pores are so small that the water will be transmitted very slowly. A clean sand of moderate texture will transmit, and therefore yield, water relatively rapidly.

In rocks, such as granite, slate, schist, gneiss, and some sandstone and shale, the water moves along bedding planes, joints, and cleavage planes so that the amount of water such a rock will yield depends on the size and number of the openings.

As rain is practically free of mineral matter, the mineral content of ground water depends on the minerals which are dissolved as the water percolates through the rock. Therefore, the mineral content of the water is largely determined by the kind of rock through which the water moves and by the length of time it is in contact with the soil and rock.

Water obtained from beneath the surface of the earth has long been used as one of the principal supplies for direct consumption by man. Springs furnished the first supplies used from the ground, and in more primitive time were a principal factor in the selection of camp, dwelling, and even town sites. In the absence of springs, wells dug into the ground to expose the water, from which water could be bailed, have been used extensively.

With the development of mechanical well drilling and pumping equipment, the use of deep wells increased, and fields of such wells were drilled to cover greater areas. This equipment led to more extensive searching to locate ground water supplies in localities favorable for new industries. Mechanical equipment also made possible the use of ground water in greatly increased volumes. Increased consumption led to shortages of supply in some areas, of the United States. Shortages in turn stimulated greater interest in variations in ground water levels and the trends in changes in levels. Eventually, the need for greater knowledge of changes in ground water levels, and rates of replenishment of supply, led to systematic studies of ground water resources. The time is coming when the State of North Carolina

will have to expand greatly its program under cooperative agreement with the U. S. Geological Survey of investigating and obtaining data regarding its ground water resources.

Topography - - The greatest influence of topography on water resources is in affecting the rate of concentration of storm water in streams. It affects the rate of percolation of water into the ground only to a limited degree, and then principally by limiting the opportunity for infiltration by shortening the length of time the water is on the land surface before reaching a stream.

The most marked effect of topography upon streams is upon the flooding characteristics. For this reason, topography is of concern to flood control engineers in analyzing stream flow characteristics. Variations in topography affect stream gradients, rates of travel of flood peaks in various sections of a stream, and the timing of the concentration of tributary flow in the main channels.

Topography is also of concern to hydroelectric engineers in selecting sites for power plants. It is a deciding element in the location of sites for dams and water supply reservoirs. Many developments of water resources can take place only where the topography is favorable for the type of projects planned. Topography has had relatively little influence in the development of major drainage basins.

Climate - - Of the many factors affecting the amount of water available in any region, the most basic is climate. Climate is the generalization of the variety of day-to-day weather conditions. Weather, on the other hand, is the condition of the atmosphere at any time or place. It is the momentary state of the atmosphere.

Climate and weather are made up of several elements, primarily temperature and precipitation, and to a lesser degree, winds and air pressure. The first two are of special importance in their relation to the distribution of water on the earth.

Temperature - - The seasons of the year are determined principally by the range in temperatures associated with them. The growing and dormant seasons are established by temperature rather than by available moisture. The evaporation of water, which is of great importance in relation to seasonal water supplies, is also governed principally by temperature.

In addition to the seasonal cycle in temperatures, a daily cycle also exists. This cycle is the variation of temperatures during daylight and darkness and is associated directly with the number of daylight hours.

The atmosphere receives only a small part of its heat directly from the sun's rays. Solar energy is absorbed by the earth's surface, and there it is converted into heat, after which the earth becomes a radiating body. It is the heat radiated from the earth's surface that produces most of the heating of the atmosphere. This process has a decided effect upon the occurrence of the maximum and minimum points in the annual temperature cycle.

The maximum and minimum average daily temperatures do not occur on the days of longest and shortest daylight hours as might be expected, but approximately one month later. Temperature has a more marked effect upon the amount of water available to man than precipitation itself. The difference in variation between average monthly precipitation from maximum to minimum and the variation in run-

off may be traced both directly and indirectly to temperature.

Temperature directly affects the rate of evaporation, which will be shown later as one of the two principal actions of the hydrologic cycle. During the hot summer months evaporation rates are high, and the water lost through evaporation exceeds that gained through precipitation. During the winter months the rate of evaporation is generally so low that the ground surface is continually wet (except when frozen) due to lack of moisture dissipation.

Temperature also affects the rate of run-off in indirect ways. It is the factor which determines the length of the growing season during which great quantities of water are consumed by vegetation. It also has marked effects on stream flow during winter months by freezing some of the surface water into an immobile state.

The period between the frost of spring and first frost of fall is generally accepted as the growing season of a region. The tremendous quantity of water used by vegetation during the growing season has a decided effect on the water resources. The demand increases gradually throughout the growing season until the plants reach maturity. The demand is so great during the peak of the season that seldom does the ground water receive any recharge. Much of the water entering the soil is used by the plants before it can percolate to the ground water table. In some cases root systems reach into the zone saturated by ground water and remove water from it directly. The wide variation in soil types and vegetation cover provides an infinite number of conditions under which the rate of vegetational use of water may be varied. Because of these wide variations in water use, no standard rates can be established for general application in determining water demands of vegetation. Irrigation will make increased demands on the water resources in future years.

Winds and Air Pressure - - Compared with temperature and precipitation, winds and air pressure are of little direct importance to water resources. Differences in air pressure act to produce wind, which is a movement of air with some velocity. The locations of differences in air pressure also give direction to the wind. The principal importance of wind is in bringing about changes in temperature and precipitation. The most important function of wind is the transportation of water vapor from the oceans to the lands, where that water vapor condenses and falls as rain.

The Hydrologic Cycle - - Precipitation and evaporation are parts of the hydrologic cycle. Rain, which is the origin of all water of the land masses on the earth, is merely a part of the hydrologic cycle. This cycle is a little beyond the comprehension of many people. In fact, there are some details of water behavior in the cycle which still baffle the best minds working in the sciences of meterology, hydrology, and allied special segments of the entire field. If we are to have a broad understanding of our water supply and its problems, we must give some attention to this cycle, for it embraces the whole mechanism of how we are blessed with fresh water on the land areas of our planet.

The sun is the major initial force that keeps the cycle functioning. The heat of the sun pouring on the surfaces of the oceans causes the water at the surfaces to evaporate. The winds pick up this vapor and, in great, sweeping movements, carry the moisture in the form of clouds over the land surfaces. The clouds thereupon chill, and the moisture forms drop-

lets, which grow into raindrops. As the second major force, gravity, takes command, the raindrops fall and start their return to the oceans. This process, evaporation from the seas, landward movement of clouds by winds, and action of gravity in causing rainfall and flow toward the oceans constitutes the most simplified framework of the hydrologic cycle.

There are, however, many complexities of the cycle, every phase of which has some bearing on how much rain is delivered and where, and what happens to it after it falls to the earth. Each portion of this great mechanism of water transport has a direct bearing on where and how we live.

The evaporation from the oceans is not uniform at any time, place, or season. Investigators have worked out averages, indicating about 6 1/4 feet per year between latitudes 8 and 30 degrees North, about 5 feet between latitudes 3 North and 20 South, and about 4 feet between latitudes 20 and 25 North. Not all of this water in the air gets carried by winds over land surfaces before it drops as rain, snow or hail, the three principal forms in which sky water reaches the earth. Some of the clouds get chilled while they are still over the oceans and spill their loads. The water cycle from the oceans to the air and return is completed by the nearest circuit.

Action by the Winds - - There are three natural patterns that lie across the face of the lands which go far toward determining our lives and the way we live them. The climate, with its important combination of temperature and rainfall, is the one which greatly determines the other two. The others are the soil, which is largely formed by the action of climate on the basic rock of the earth, and the vegetation, which is determined by both climate and the type of soil in an area.

The main air currents catch the clouds that have been borne from the sun's warmth on the oceans and move them landward. Two examples of how these clouds reach the points where they spill their loads follow.

The great, curved flow of air sweep from the Gulf of Mexico gathers clouds and moves toward the body of the United States. In general, the line of travel is up through Texas, swinging slightly eastward all the while, toward the Great Lakes and New England. The rising warm air from the Texas flat country may enter the cloud stream, elevating it higher into cooler layers above. The cool air condenses the vapor in the clouds, whereupon rain or showers fall along the coast or in the interior of Texas, Oklahoma or Arkansas. The cloud stream may not, however, drop any or much of its water during this portion of the journey. As it travels on in a slightly northeasterly direction, there may be another major air current sweeping Southeasterly from Northwestern Canada.

When these two major air currents meet, the cold air being heavier slides under the lighter layer of warm air, shoving the Gulf air stream higher and higher until the moisture-carrying air is chilled and spills its load in the form of rain. The two masses of air may meet head on and push against each other, the cold face of the northern air chilling the warmer air as they meet. Sometimes they hang over the land below, whereupon the heavens pour for hours, occasionally causing floods across the land.

The heaviest precipitation in the continental United States occurs near the seacoast cities of Grays Harbor and Hoquiam in Washington. The moist air comes in off the Pacific Ocean, super-loaded in some degree by the warm Japanese Current. As the winds shove the clouds in across Grays Harbor and Hoquiam and

their seacoast area, the clouds are piled against the Olympic Mountains. The winds move in strongly, pushing the cloud masses up the westerly slopes of the peaks until they are raised into the higher and colder layers, causing rainfall. The average annual precipitation at Grays Harbor and Hoquiam is about 160 inches. There are spots just east of the highest Olympic crests where the land receives less than one-tenth of the amount of rainfall on the west side of these peaks. Most of the water in the clouds has been removed before they cross the Olympic highlands.

Action by the Soil - - The moment raindrops reach the ground, a very complex struggle begins. The water is determined to return to the ocean, with gravity pulling it along. Other forces, however, reach for the water to delay it, so that it may be of some service before it returns to the ocean.

Thirsty soil is one of the major competitors for water as it reaches the land surfaces. If the soil surface is open, porous, and able to let the water percolate down into the earth below, it is held where it falls. As the moisture filters downward, each little soil particle is filmed with water, which plants can pull into their coverings. The excess will continue to sink into the sub-soil until it reaches some impervious layer of tight clay, shale, or rock. There it will continue to follow the slope of the underground layer and may enter some of the greater storage areas that form artesian basins, where it is held by tight earth layers above and below. This underground water may keep on flowing in some subterranean channel until it comes into the sunlight again as a seep or spring after a few or many miles of blind seeking for a way to return to the ocean. In some locations it may travel all the way underground to the seashores, shoving against the salt water in an effort to merge into the ocean. The water which is trapped by soaking into the deep soil, or which is pulled into the soil by gravity from stream bottoms, lake bottoms, and shore lines, is known as ground water, some of the best and most abundant usable water we have. Wells trap this water, which is caught, lifted, and used as it strives to complete its part of the hydrologic cycle.

When the rains fall in such abundance that the soil can not absorb them, the water starts overland toward the ocean. A soil that has been overused, has been grazed beyond its carrying capacity or has been badly farmed and has eroded down to clayey types without any spongy organic matter to protect the surface, will slick over and shed water like a tin roof. Tight soils will quickly become saturated in the upper inches and, because they absorb slowly, cannot take in the water of extra-heavy rains. A frozen soil will not absorb surface water. Any of these and similar conditions will cause water to flow swiftly overland down slope to the nearest channels of creeks and rivers to swell the return progress of the sky water toward the ocean. Sometimes there is excessive run-off, and floods occur.

Causes of Floods - - There are two general types of storms that cause floods, (1) the type which includes the quick, local downpour, the big thunder storm and the cloudburst, and (2) the meeting of a large body of moisture-laden air, moving inland from the South, with a body of cold air from the polar regions, as previously described in connection with the air sweep from the Gulf of Mexico and the major air current from Northwestern Canada. Another condition which causes major floods, and some of the worst, occurs when there is a blanket of snow on the ground, the earth is frozen and can not take in water, the weather suddenly turns warm, there may be rain which is warmer than the snow, and the melting snow sluices into streams along with fallen rain.

Run-off - - The water that takes the overland route, as well as springs and seeps, supplies the water which flows in our streams. The many and devious routes which this part of the precipitation travels have many baffles and blocks that continually divert the water. The water which finally gathers in our rivers to flow to the sea is the total run-off from the land. Which each year is only 8.7 inches of the total average annual precipitation of 30 inches. The 21.3 inches, lost between the time at which the sky water reaches the earth and the time at which the rivers pour their water back into the ocean has gone back into the air in two forms, (1) surface evaporation from the soil and (2) transpiration of plants, pulling on water through their little hair roots and exhaling moisture through the pores of their tissues. This loss or diversion into the air of water through plants or soil surface is known as evapo-transpiration.

While the average run-off for the entire United States is reckoned at 8.7 inches of the total of the 30-inch average precipitation, more than half of the country has an annual rainfall of less than 5 inches. The rain pattern, the climate, the soil, and other factors enter into how much water may feed into the streams. There are vast areas west of the 97th Meridian where the rainfall is so sparse, the plants and soil so thirsty, and the air so dry that there is practically no run-off whatever.

Droughts - - The climate is changing from day to day, year to year, and century to century. It fluctuates toward a colder, more moist type of climate over some years, then back toward warmer, drier days; it does somewhat the same in greater cycles over centuries. There was a fairly wet period between 1850 and 1870. Between 1884 and 1895 there was the greatest aggregate of rainfall reported for such a period. Beginning with 1894 more and more station reported less rainfall. The low in rainfall came during drought years of the 1930s. It rained more at more places during the 1940s. In 1949 the climax of a three-year drought in the northeastern states occurred.

Our scientific people are not in agreement with each other as to there being any cycle in droughts. One authority points out that there have been droughts as close together as one year, in 1895 and 1896. He cites a lapse of seven years between the droughts of 1910 and 1917, and fourteen years between the latter drought and the beginning of the drought of the 1930s. Another authority found, at least to his satisfaction, that there was a repeating cycle in the weather on a 23-year basis.

Drought comes when there is a lack of rain and a rise in temperature, the main conditions of drought. Then the hydrologic cycle does not deliver enough water to the land to meet the demands of plant life as it transpires water into the air, to meet the evaporation from the ground surface, and still provide the surplus to keep streams running at their proper level.

Just so long as the sun keeps pouring heat energy on the oceans, it will draw vapor up into the winds which will carry it landward. We may have less rain locally or nationally in periods of the immediate years ahead; we may have more. Yuma, Arizona, may have over $2\frac{1}{2}$ times as much as its average rainfall as it did in the ten years ending in 1905, or it may have only 14 per cent of the average as in the ten years ending in 1901. Boston, with an average of 40 inches of precipitation, may drop to 68 per cent of that, as it did in the 10-year period ending in 1901, or it may have wet years as before 1863 when the 10-year average was 169 per cent of normal.

Effects of Regional Characteristics - - North Carolina, as a single region or as a group of smaller regions, has many characteristics. Each exerts a different influence upon the nature of the water resources. Many of these characteristics overlap in varying degrees and combinations to produce a multitude of conditions affecting the amount and distribution of water.

The climate conditions provide primary controls over the total amount of water that is available and its distribution throughout the year. The geologic and topographic conditions provide secondary controls, principally over the time factor in distribution. The combination of soils, vegetation, topography, temperature, and rainfall collectively determine the amounts of water that occur in the ground and on the surface during the various months of the year.

Situation in 1949 - - The climax of a three-year drought in the northeastern states was causing worry and trouble in 1949. By July 15 of that year, bellboys at beach-side hotels in Connecticutt were carrying buckets of water to guests, and baths in showers and tubs were prohibited. Fifty families in one neighborhood in the outskirts of Narragansett were carrying water from an old well that had served for half a century.

Maine forests were tinder dry and would flame to ashes if fires got started. Game and fish authorities faced another problem. Water was getting short in fish hatcheries. Young fish had to be moved from the rearing ponds to suitable streams. Such streams were difficult to find, because channels in which young trout were normally placed were 50 to 75 per cent dry, so low that trout fry had no chance of survival.

New York City speeded extensive plans to prevent recurrence of such a water shortage. Some proposals included the cleansing of the water of the Hudson River so that its flow might be made usable for water supply. Other communities, made water-conscious by the shortages of the year, looked ahead and planned for a more adequately assured supply.

Rains came. The drought in the northeastern states was broken. The annoyance of no shaves, no baths, and no-water-without-asking in cafes passed. Many people forgot the water worries of those days and turned their attention to war threats, congressional investigations, and baseball standings.

The combination of continued drought and high demands that caused trouble to New York and New England communities in 1949 could not be set up as proof that people in the United States were facing a general, catastrophic water shortage in the immediate future. Such experiences should, however, be regarded as bright-flashing danger signals meaning that, unless the abuse and misuse of water wealth is checked and sound principles of conservation and proper use of water are adopted, more and more water shortages will occur. These warning signals flashed again in 1953 and 1954.

Availability of Water - - The answer to the question as to whether there is a water shortage can be answered "yes" or "no". There have been shortages, well-defined and clearly demonstrated, in many locations in the United States. In the broad view, however, there is plenty of water. As stated in the preceding chapter, if the average annual precipitation in the United States were spread evenly over the country, it would amount to about 30 inches of rainfall on every acre. The trouble is that it does not spread evenly, and the precipitation in any one locality does not come with seasonal regularity or maintain a constant average from year to year, as previously indicated. There is plenty of water. Only a small fraction of the total supply of water, however, is suitable for human, municipal, industrial and agricultural uses, the uses of water that underwrite American living.

Effects of Scarcity of Water - - A water shortage of real magnitude in any community can close a factory. It can cause the stock owned in some enterprise to depreciate in value. Lack of water or the effect of bad water can reduce or actually destroy the productive capacity of a farm. A major water shortage can blight an entire community. Regardless of these effects, however, we have, until recently, viewed water as having a unique position in the basic resource wealth of the nation. We have harbored the illusion that it is inexhaustible. Water resources are not inexhaustible.

Water Problems in Other Localities - - It might be helpful, in considering North Carolina water problems and determining what should be done about them, to review water problems in other localities and to learn what was done, and is being done, with respect to them.

Extreme impetus of World War II to industrial expansion caused demand on ground water supplies to increase from 4.5 million gallons per day in 1934 to 22.5 million gallons per day during the war. The water level in one 1,000-foot well dropped 102 feet below sea level. Another well, 610 feet deep, pulled down to where water was 165 feet below the surface of the sea. The fresh water, flowing through underground layers, could no longer push back the water of the Gulf of Mexico, and the wells began to deliver ocean brine, which is unpalatable and immediately snarls industrial operations in a plant constructed to use fresh water. Industries began to use water from the Brazos and Nueces Rivers, which provide adequate supplies of water. Texas City faces problems if the watersheds of these rivers are damaged, if heavy withdrawals of ground water near headwaters dry up springs, or if agricultural practices increasingly hold water back to serve crops.

Bristol, Pennsylvania, originally drew its water supply from the Delaware River. The river was a convenient place for dumping wastes, and it became so foul that the city sank seven wells in 1940 to secure clean water. The wells delivered 700 gallons when first pumped. Then the water table dropped to the bottom of the wells, and only 200 gallons per minute, an insufficient suppply, could be pumped. Bristol had to use again the poisonous waters of the Delaware River and pay the heavy cost of filter installations, treatment equipment, and other facilities.

The Philadelphia-Camden area is so close to the limit of industrial expansion that it must depend on daily pumping from sands underlying the metropolitan district and pumping of deeper sands may be necessary. A large part of the recharge of sands underlying Philadelphia comes from water percolating from the Schuylkill River, once a decent, clear, beautiful stream but now a filthy and polluted flow. If the withdrawal from ground water areas becomes excessive, lines of percolation from this river may become established, and the filthy water sluicing in would ruin all water in underground storage. Once so contaminated, a ground water reservoir remains so for many, many years.

Atlantic City pumped its water supply from upper layers of water-yielding sand. It pumped too heavily; salt water came in. Wells were driven into deeper sands. The first of these wells, driven in 1893, flowed 20 to 25 feet above sea level. In recent seasons, the water level in wells tapping this water-charged subterranean reservoir has dropped to 85 feet below sea level.

Los Angeles is reaching farther and farther into the hinterland to obtain adequate supplies of water. Cincinnati is using wells in the Miami River Valley in addition to its original sources in Mill Creek Valley.

A pumping rate of 32,000,000 gallons daily at Savannah produced a drop in the ground water level to 32 feet below sea level, causing worry regarding possible salt water intrusion in the future. Increase in irrigation wells in the Panhandle of Texas from about 300 wells in 1936 to 8,500 wells in 1948, irrigating about a million acres, caused drops of water tables ranging from 9.6 feet to 30.6 feet. Baltimore is worried over salt creeping into its wells. Long Island is troubled by over-use of available water supplies. New Jersey is facing a growing demand for water for irrigation purposes. Other

areas of the East are in the same quandary. Water levels are declining near Memphis. Salt water is encroaching in shallow sands at Mobile. The Miami district in Florida has been battling a compounded problem of drainage, pollution, and salt water intrusion with solution of all of the troubles not yet achieved. Chicago is overpumping some of its ground water supplies. Peoria is facing a critical shortage. The Lake Charles area of Louisiana, where growing of rice demands great volumes of water, faces curtailed production unless additional supplies are developed. The Grand Prairie region of eastern Arkansas is pumping about two times the amount of the annual ground water recharge.

Withdrawals of Water - - The following table indicates estimated average daily withdrawals of water in the United States in 1950.

USE	FROM STREAMS & LAKES (bgd) (2)	FROM WELLS (bgd)	TOTAL (bgd)	PER CENT OF TOTAL	PER CAPITA (gpd) (3)
Rural (4)	0.7	2.9	3.6	2	68
Municipal (5)	5.0	1.8	6.8	4	
Industrial (6)					
Steam-Electric Power			(37.0)		(244)
Steel			(13.4)		(88)
Petroleum Refining			(7.6)		(50)
Wood Pulp & Paper			(4.2)		(28)
Other			(21.8)		(143)
Total Industrial	76.7	7.3	84.0	48	553
Irrigational	61.2	19.4	80.6	46	532
Total	143.6	31.4	175.0 (1)	100	1,153
Water Power (7)	1,110	--	1,110	--	7,320

(1) The total of withdrawals is greater than the amount of water in use; much of the water withdrawn at a given point is not consumed, and the residue may return to the source and be withdrawn again at another point. Thus, the quantities in the table include considerable, but unknown, duplication by reuse.
(2) Billion gallons per day. The East commonly measures water in million gallons a day; the West, in acre-feet. One acre-foot is the volume of water necessary to cover an acre 1 foot deep. A million gallons is equivalent to 3,069 acre-feet.
(3) Gallons per day.
(4) Irrigation excluded.
(5) About half the water taken into municipal systems is distributed to industries. The amounts shown here are the half ascribed to non-industrial use.
(6) Includes about 12.6 bgd of brackish water.
(7) Ordinarily not a withdrawing use; here given for comparison. The indicated quantity sums up many reuses.

In comparing withdrawal of water with the supply of water naturally available, net natural supply can be taken as approximately equal to the mean run-off in the streams. Total withdrawal in 1950 was about 15 per cent of mean run-off.

For several reasons, this comparison should not be construed that the nation has no water supply stringency at this time and will not face greater stringencies in the future. The principal reasons are as follows:

(1) The net supply is available only in the sense that all the run-off in streams conceivably might be impounded and then released, minus that lost by evaporation, as required for use. Obviously, however, regulation so complete is wholly impractical.

(2) Many streams are remote from areas of use. Their run-off may be available but inacessible.

(3) The flow of most streams varies widely. The minimum natural flow in few of them is probably more than about 20 per cent of average flow. Also, run-off is commonly least when water requirement is greatest, and high run-off occurs in seasons when water requirement is low. In other words, run-off is not advantageously distributed as to time.

(4) Run-off varies greatly from place to place. There is considerable, even great, difference in degree between the geographic distribution of withdrawals. In other words, run-off is not distributed uniformly as to place. For example, the run-off yield from the Columbia River basin and the Pacific Slope in Washington and Oregon is roughly equal to that from all the remainder of the United States west of the Mississippi River.

Considering these several reasons, and also allowing for reuse, requirement for water now probably are in about the same order of magnitude as the minimum net natural supply. At one place or another in most parts of the country, requirement exceeds minimum natural supply and has been met, either by impounding stream waters, or depleting ground water storage, or salvaging, to a small degree, water that naturally would be evaporated or transpired. In other words, even current withdrawals require impoundments or other measures to augment natural water yield. At some places and at certain times the stringency is severe.

Uses of Water - - Fortunately, water resources are being replenished constantly. If we can learn to work with our enviroment instead of against it, we'll find we have more water available to us than we seem to have at present. In the strict sense, water is never lost. No matter what we do with it, water finds its way back into the natural cycle. It might thus be argued that it makes no difference what water is used for, or how it is used. Actually, what happens to the water is a matter of extreme importance, because various uses borrow water from the natural cycle for longer or shorter periods and because there are often significant differences in how and where the water is returned. These differences may be enough to upset local supplies.

To start with, many uses involve little or no disturbance of nature's cycle. Water in lakes and streams goes its way unaffected by the sailing and swimming of recreation seekers, or by the passage of craft navigating its lower reaches. Natural water supplies like these breed fish and support waterfowl and other forms of wildlife. And it should not be forgotten that most of our farms depend on rainfall and hence use water without taking it from the natural cycle.

Many uses represent only the most trifling borrowings and do not significantly affect the immediately available water resources of the region. Water merely passes through turbines of the hydroelectric plant and condensers of the steam power plant. Hydroelectric use changes only potential energy. Condenser use, like many industrial cooling processes, changes only temperature.

Uses that immediately reduce availability to the region are likely to be critical. Much of irrigation water, for example, goes back to atmosphere by evaporation and transpiration. It man, or may not, return to the region as rainfall. Thus, the farmer using well water for sprinklers may cause a net reduction in the region's ground water supplies. The factory owner who installs a recharge well returns much of his withdrawal to essentially the same place in the cycle and at nearly the same time.

The state in which the water is returned also constitutes a significant difference. A municipal system draws water from the stream, and a sewer system discharges back into the stream. If these wastes, and those of the industries using the stream, are treated, little net change in the region's available water occurs. If wastes are not treated, however, the entire downstream flow may become badly polluted, and its usefulness may be diminished or even completely lost. This loss effects a reduction in the supplies of the region.

Foreseeable Requirements - - Uses for water are increasing ever more rapidly in all categories. Household appliances requiring more water are the order of the day. Automatic washers and garbage disposers in the home, and year-round air conditioners in the home and office, comprise a few of such appliances, which are no longer strange items in our rural communities. There is every reason to expect such appliances and facilities to become commonplace. In other words, per capita water requirement, merely for living under a rising standard, can be expected to increase steadily.

Foreseeable requirements of industry are almost confounding. Merely in proportion to our growth in population and our greater responsibility in world affairs, demand for the products of our industry and the requirement for water to manufacture them will rise substantially. A more critical situation on the other hand is that we are using raw materials of lower grade and ever more commonly are turning to products of checical synthesis as substitutes for natural materials. It requires more water to wash, grade, and otherwise prepare the lower-grade raw materials. Without exception, the products of synthesis require much more water than the natural materials they replace. For example, rayon and nylon require many times more water than natural fibers, and synthetic rubber requires many times more water than natural rubber. With many natural materials in short supply and synthesized substitutes commonly superior in quality, we can expect greater reliance on the synthesized materials. This situation is being compounded by new processes of synthesis for which the raw materials may be grown as a crop. Growing such crops, however, will require either soil water or irrigation water. A reasoned estimate of the end-point seems more remote with every year that passes.

The following table presents an estimate of water requirements, in the United States, in 1975. The basis of estimate appears reasonably conservative. The term of projection is all too short a time in which to make the water supply adjustments that are implicit in the estimate.

ESTIMATED WATER REQUIREMENTS IN THE U. S. AS OF 1975

USE	BILLION GALLONS PER DAY	PER CENT OF TOTAL	PER CENT OF 1950 WITHDRAWAL	PER CAPITA (gpd)
Rural and Municipal (1)	15	4	145	78
Industrial	225	64	270	1160
Irrigational	110	32	135	570
Total	350	100	200	1,810

(1) About half the water taken into municipal systems is distributed to industries. The amounts shown here are the half ascribed to non-industrial use.

This estimate provides reason for concern. It foresees a doubled water requirement. The rate of percentage increase would be the same as has been experienced in the last half century. It foresees an industrial requirement two and a half or three times that of the present.

Water Shortages in the United States - - Many public water-supply systems were affected by the widespread 1953 drought according to a report entitled "Public Water-Supply Shortages, 1953", which was recently made available by the U. S. Geological Survey. The results of an inventory of the entire 48 states reveal that 1,072, or 6 per cent, of the public water-supply systems were unable to meet the peak demands of their customers. These results mean that about 15 of every 100 persons, using public supply systems, were affected. The only states reporting no shortages were Idaho, Mississippi, and Rhode Island.

The greater part of the shortages (51 per cent) were found to be due to municipalities outgrowing their water-supply systems; 1 per cent to increased industrial use; 34 per cent to supply failure; and 14 per cent to a combination of reasons. Most of the shortages were experienced by small towns and cities. Of the 1,072 municipalities studied, 54 per cent used ground water, 39 per cent surface water, and 7 per cent both ground water and surface water.

Drought in the United States occurred for the second time in 1954. In the spring of that year, prolonged unseasonal drought, built up over periods of six months to six years in various sections of the country, caused dust to fly and water supplies to dwindle. Conditions became more severe as a result of the drought in late summer and early fall.

Hoover Dam's firm power commitment was cut 12% because of the low level of Lake Mead, the reservoir behind Hoover Dam. Forty Southern Illinois towns faced severe municipal water shortages due to a continuing two year drought condition. Of these towns, East St. Louis and the Mattoon-Effingham regions were in the worst condition. New records for low stream flow were set in the drought stricken area, with many streams showing less than 5% of normal flow for the past 12 months. Twenty-seven reservoirs for municipal supplies had less than 8 months supply on hand. Some were nearly empty. Water was hauled long distances. For two months a considerable part of the Southeast had record-heat with rainfall as low as one-third of normal. In North Carolina, the municipal governments of Gastonia, Lincolnton, Greensboro and Burlington effected stringent measures, such as rationing of water for family consumption and no water for sprinkling lawns, washing automobiles, and drinking in cafes and restaurants unless demanded, because of severe water shortages. On Colorado's

eastern slope, Denver, Colorado Springs, Boulder, Pueblo, and Fort Collins were water-short all summer. Lincoln and Grand Island in Nebraska suffered deficiencies in public water supply. Texas cities were plagued with serious continuing problems of water resources development. There were severe troubles in small towns in Kansas which lack adequate wells or sufficient water storage. Four emergency water supply units of the U. S. Public Health Service were in operation.

This was principally the farmer's drought. Everywhere, it was the farmer, his family, his livestock, and his crops that were suffering. In Georgia, 60% of the agricultural crop was affected by current drought conditions. Missouri had a total assistance fund of $10,900,000. Most of this amount was spent to purchase hay and defray its transportation costs. President Eisenhower designated 76 counties, mostly in Southern Missouri, as drought disaster areas eligible for Federal aid.

Water Shortages in North Carolina - - Over the years the water cycle remains in approximate balance. So far as available evidence indicates, essentially no water is added to, or lost from, the circulation permanently. Also, there is no present indication that any act by man can substantially increase the amount of water in circulation.

From this ever-varying circulation the State, its people, agriculture, commerce, and industry, must satisfy its ever-mounting and relatively insatiable thirst. Perennially, water cannot be withdrawn from the circulation at a rate exceeding run-off plus whatever is salvaged by intercepting water that otherwise would evaporate or be transpired. Any greater withdrawal will be at the expense of permanently diminishing ground-water or soil-water storage, or both. This limitation applies to each basin or other distinct water-yielding area. It is meaningless for the State as a whole, because an excessive withdrawal in any one basin disrupts the balance in the water circulation of that basin and is not compensated by a surplus of water that might exist elsewhere.

North Carolina has experienced serious water shortages during the past two years, affecting public, industrial, and agricultural water supplies. An example of the magnitude of the monetary loss to agriculture alone caused by the 1954 drought is roughly estimated at 50 million dollars. It must be realized that this figure is an estimation based on major crops of substantial quantities, being the difference between the normally expected crop yield and price, and the actual yield and price. This does not include losses due to pasture, livestock, industry and many intangible losses. It is reasonable to assume that if all of the losses in the counties affected and their relation to the economy of the state as a whole are considered, the above figure would be more than double.

Public water supplies that were affected in 1953 and 1954 amounted to 14 per cent of the towns in North Carolina. In the Mountain Region 16 towns were affected, of which 14 were surface water supply and 2 ground water. The Piedmont Region had 22 towns affected; 17 were surface supply and 5 ground water supply. In the Coastal Region 6 towns were affected, 4 being supplied by ground water and 2 by surface water. (For location on Map see Plate #2, N. C. State Planning Board, Report on Water Resources 1937). (Information above and table from Sanitary Engineering Division, State Board of Health).

TABLE 1

TOWNS IN NORTH CAROLINA THAT EXPERIENCED WATER SHORTAGES DURING THE YEAR 1953

TOWN	REGION	RIVER BASIN	SOURCE OF SUPPLY
Asheville*	Mountain	French Broad	Surface Water
Black Mountain	Mountain	French Broad	Surface Water
Hot Springs	Mountain	French Broad	Surface Water
Marshall	Mountain	French Broad	Surface Water
Weaverville*	Mountain	French Broad	Surface Water
Bryson City	Mountain	Little Tennessee	Surface Water
Burlington	Mountain	Little Tennessee	Surface Water
Marion	Mountain	Catawba	Surface Water
Old Fort	Mountain	Catawba	Surface Water
Ridgecrest*	Mountain	Catawba	Surface Water
Murphy	Mountain	Hiwassee	Surface Water
Candor	Piedmont	Yadkin	Ground Water
Mount Pleasant	Piedmont	Yadkin	Ground Water
Cary	Piedmont	Neuse	Ground Water
Roxboro	Piedmont	Neuse	Surface Water
Mebane	Piedmont	Cape Fear	Surface Water
Pittsboro	Piedmont	Cape Fear	Surface Water
Raleigh*	Piedmont	Cape Fear	Surface Water
Sanford	Piedmont	Cape Fear	Surface Water
Ahoskie	Coastal	Chowan	Ground Water
Goldsboro	Coastal	Neuse	Surface Water
Selma	Coastal	Neuse	Ground Water
Windsor	Coastal	Roanoke	Ground Water

TABLE 2

TOWNS IN NORTH CAROLINA THAT EXPERIENCED WATER SHORTAGES DURING THE YEAR 1954

TOWN	REGION	RIVER BASIN	SOURCE OF SUPPLY
Little Switzerland	Mountain	French Broad	Ground Water
Blowing Rock	Mountain	Watauga	Surface Water
Lenoir	Mountain	Catawba	Surface Water
Newland	Mountain	Catawba	Ground Water
Valdese	Mountain	Catawba	Surface Water
Bisco	Piedmont	Yadkin	Ground Water
Lexington	Piedmont	Yadkin	Surface Water
Mocksville	Piedmont	Yadkin	Ground Water
Thomasville	Piedmont	Yadkin	Surface Water
Troy	Piedmont	Yadkin	Surface Water
Apex	Piedmont	Neuse	Surface Water
Roxboro*	Piedmont	Neuse	Surface Water
Greensboro	Piedmont	Cape Fear	Surface Water
Ramseur	Piedmont	Cape Fear	Surface Water
Sanford	Piedmont	Cape Fear	Surface Water
Gastonia	Piedmont	Catawba	Surface Water
Lincolnton	Piedmont	Catawba	Surface Water
Kings Mountain	Piedmont	Broad	Surface Water
Reidsville	Piedmont	Roanoke	Surface Water
Selma	Coastal	Neuse	Ground Water
Wilson	Coastal	Neuse	Surface Water

* Towns that have taken action to improve their water supply.

Many of North Carolinas counties experienced serious droughts during 1953 and 1954 which materially affected the economy of the counties, and of the State as a whole. The resulting situation is exemplified by a study of the regions and river basins in which these drought occurred. During 1953, the economic losses to agriculture, industry, and the general public were so great that twenty counties were declared drought areas by the Federal Government and were given Federal aid. In 1954, thirty-nine counties were declared drought areas, and thirteen additional counties applied for Federal aid, which had not been granted at the conclusion of the study. Fifteen counties suffered serious losses during both 1953 and 1954, being declared drought areas both years. Twelve of these counties are adjacent, being located in the northeastern part of the Piedmont Region, and three of them are located in the northwestern area of the Piedmont Region. In general, the major drought area during 1953 was in the northeastern part of the Piedmont Region. In 1954, the drought was more wide-spread, affecting almost all of the Piedmont Region, the eastern part of the Mountain Region, and the southwestern part of the Coastal Region. The most serious drought occurred in the southern part of the Piedmont Region from Anson County through Rutherford County.

Study of these drought areas, and county and town public water supplies, indicates the ever-increasing need for conservation of the State's water resources. Although we have ample average rainfall, and average flow in our streams and rivers, the supply is not evenly distributed by nature to give the maximum, or in many cases an average, economic balance for agriculture, industry, and public water supplies. More knowledge, and planned conservation of the State's water supplies, both surface water and ground water, are prerequisite for continued prosperity, increasing development, and the general welfare of North Carolina.

TABLE 3
COUNTIES IN NORTH CAROLINA THAT WERE GRANTED FEDERAL AID DUE TO DROUGHT DURING THE YEAR 1953

COUNTY	REGION	RIVER BASIN
Surry	Piedmont & Mountain	Yadkin
Iredell	Piedmont	Yadkin & Catawba
Alexander	Piedmont	Catawba & Yadkin
Alamance	Piedmont	Cape Fear
Chatham	Piedmont	Cape Fear
Guilford	Piedmont	Cape Fear
Lee	Piedmont	Cape Fear
Durham	Piedmont	Neuse & Cape Fear
Orange	Piedmont	Neuse & Cape Fear
Wake	Piedmont	Neuse & Cape Fear
Person	Piedmont	Neuse & Roanoke
Rockingham	Piedmont	Cape Fear & Roanoke
Franklin	Piedmont	Tar
Granville	Piedmont	Tar, Roanoke & Neuse
Vance	Piedmont	Tar & Roanoke
Warren	Piedmont	Tar & Roanoke
Caswell	Piedmont	Roanoke
Halifax	Coastal	Roanoke & Tar
Harnett	Coastal	Cape Fear

TABLE 4

COUNTIES IN NORTH CAROLINA THAT WERE GRANTED FEDERAL AID DUE TO DROUGHT DURING THE YEARS 1953 AND 1954

COUNTY	REGION	RIVER BASIN
Surry	Piedmont & Mountain	Yadkin
Randolph	Piedmont	Yadkin & Cape Fear
Iredell	Piedmont	Yadkin & Catawba
Alexander	Piedmont	Catawba & Yadkin
Alamance	Piedmont	Cape Fear
Chatham	Piedmont	Cape Fear
Durham	Piedmont	Neuse & Cape Fear
Orange	Piedmont	Neuse & Cape Fear
Person	Piedmont	Neuse & Roanoke
Rockingham	Piedmont	Cape Fear & Roanoke
Vance	Piedmont	Tar & Roanoke
Granville	Piedmont	Tar & Roanoke
Warren	Piedmont	Tar & Roanoke
Franklin	Piedmont	Tar
Caswell	Piedmont	Roanoke

TABLE 5

COUNTIES IN NORTH CAROLINA THAT WERE GRANTED FEDERAL AID DUE TO DROUGHT DURING THE YEAR 1954

COUNTY	REGION	RIVER BASIN
Ashe	Mountain	New River
Alleghany	Mountain	New River
Burke	Mountain & Piedmont	Catawba
Rutherford	Mountain & Piedmont	Broad
Polk	Piedmont & Mountain	Broad
Caldwell	Piedmont & Mountain	Yadkin & Catawba
Iredell	Piedmont & Mountain	Yadkin & Catawba
Surry	Piedmont & Mountain	Yadkin
Wilkes	Piedmont & Mountain	Yadkin
Alexander	Piedmont	Yadkin & Catawba
Union	Piedmont	Yadkin & Catawba
Cleveland	Piedmont	Broad
McDowell	Piedmont	Catawba
Catawba	Piedmont	Catawba
Gaston	Piedmont	Catawba
Lincoln	Piedmont	Catawba
Mecklenburg	Piedmont	Catawba
Cabarrus	Piedmont	Yadkin
Davie	Piedmont	Yadkin
Montgomery	Piedmont	Yadkin
Rowan	Piedmont	Yadkin
Yadkin	Piedmont	Yadkin
Randolph	Piedmont	Yadkin & Cape Fear
Alamance	Piedmont	Cape Fear
Chatham	Piedmont	Cape Fear
Durham	Piedmont	Neuse & Cape Fear
Orange	Piedmont	Neuse & Cape Fear
Person	Piedmont	Cape Fear & Roanoke
Caswell	Piedmont	Roanoke
Rockingham	Piedmont	Roanoke & Cape Fear

TABLE 5, CONTINUED
COUNTIES IN NORTH CAROLINA THAT WERE GRANTED FEDERAL AID DUE TO DROUGHT DURING THE YEAR 1954

COUNTY	REGION	RIVER BASIN
Orange	Piedmont	Neuse & Cape Fear
Person	Piedmont	Cape Fear & Roanoke
Caswell	Piedmont	Roanoke
Rockingham	Piedmont	Roanoke & Cape Fear
Franklin	Piedmont	Tar
Vance	Piedmont	Tar & Roanoke
Warren	Piedmont	Tar & Roanoke
Granville	Piedmont	Tar, Roanoke & Neuse
Anson	Piedmont & Coastal	Yadkin
Scotland	Coastal	Yadkin
Hoke	Coastal	Yadkin & Cape Fear
Richmond	Coastal	Yadkin
Cumberland	Coastal	Yadkin

TABLE 6
COUNTIES IN NORTH CAROLINA THAT APPLIED FOR AND DID NOT RECEIVE FEDERAL AID DURING THE YEAR 1954

COUNTY	REGION	RIVER BASIN
Watauga	Mountain	Watauga & New River
Henderson	Mountain	French Broad
Davidson	Piedmont	Yadkin
Moore	Piedmont	Cape Fear & Yadkin
Guilford	Piedmont	Cape Fear
Wake	Piedmont	Neuse & Cape Fear
Bladen	Coastal	Neuse & Cape Fear
Harnett	Coastal	Neuse & Cape Fear
Sampson	Coastal	Neuse & Cape Fear
Johnston	Coastal	Neuse
Nash	Coastal	Tar & Neuse
Wayne	Coastal	Neuse
Wilson	Coastal	Neuse & Tar

Reasons for Water Shortages - - Nature supplies ample rainfall in most parts of the United States. People are wondering, therefore, why water shortages in major cities occur, why industrial expansion is governed to an ever greater extent by water availability, and why vast sums are spent on development of public water projects. Aside from local droughts, there are three main reasons for water shortages.

One reason is that needs for water, many and varied, continue to increase rapidly. Increase in population forms the basis of water problems. The ever-rising living standards of the people greatly augment the problem. More water is demanded for individual sanitation and confort, which constitute by far the highest average per capita usage. Demands are made on agriculture and industry for more and more projects and services, in the making of which water is used, often in large quantities.

A second reason is that needs run out of balance with supply in many areas. Neither water nor the demand for it is evenly distributed. Rainfall varies from section to section. Some areas enjoy plentiful surface-water supplies (streams and lakes), while others must use ground water. Differences in water wealth undoubtedly influenced the development pattern of the United States. Many other factors, however, were at work.

The third reason is that, because of these factors, great concentrations of population and industry occur. The demands of these concentrations cannot be met from strictly local supplies. Agriculture expands in water-poor regions. The solution of problems in both of these cases may be found in large-scale diversion of water from regions of surplus to regions of need.

Payment must be made for past squandering and abuse of water resources. In many areas, supplies of ground water have been temporarily depleted, and in some cases, ruined. Unchecked dumping of waste has resulted in pollution of surface-water resources, making them unusable for some purposes. These conditions indicate the urgent need for wiser utilization and more effective conservation and development of our water resources.

CHAPTER III--USE OF WATER FOR DOMESTIC AND MUNICIPAL PURPOSES

Nature of Use - - The use of the State's resources for domestic and municipal water supply constitutes the highest and best use. Such use must have first priority in the consideration of water resources development.

The domestic and municipal use of water is universally classified as the most important use of that resource. Water is essential to life, the life of a city as well as the life of a human being. Without water, a man dies. Without water, a community faces the same fate.

Although comparatively small in amount, as compared to the total water used, domestic and municipal water supplies constitute the most basic requirement for urban development. Urban life cannot exist except where adequate water resources of satisfactory quantity and quality are available for domestic and municipal purposes. Domestic and municipal water supply is the most universal of all uses of the nation's water resources, affecting every state and city, and most villages. Approximately two-thirds of the population of the United States now enjoy and are dependent upon such supply.

In appraising water uses in this country, the major domestic uses are included in that segment of uses usually referred to as municipal uses of water supply. This category also includes water for fire protection, street flushing, lawn sprinkling, recreational, and other public uses; water for commercial establishments; and a part of the water supply for industry.

Accelerating demands for water by cities are beginning to add up to a significant load on the water resources of the United States. In many parts of the country, the total use of water is reaching physical or economic limits. Evidence indicates that the use of water by municipalities tends to show a greater rate of increase than all other uses.

Notwithstanding increasing costs in recent years, water is one of the least expensive, essential commodities that the public buys. Annual domestic water charges in the United States average only $6. per person, or less than two cents per day. In general, domestic water is procured, filtered, pumped, and distributed at the small cost of less than five cents per ton.

Per Capita Use - -The per capita use of water distributed by water works is increasing. By 1945, the Public Health Service reported an average in the United States of 127 gallons per capita per day, varying from 60 gallons in communities of 500 population to 140 or 150 gallons in cities of 10,000 and over. Growing commercial and industrial activity, lawn sprinkling and semi-agricultural uses, air conditioning, and generally higher standards of living and cleanliness explain, in large part, the increase in use.

Higher-than-average per capita use, taken alone, is not always proof of wasteful use or excessive leakage. Some cities use as much as 300 to 500 gallons per capita per day without waste, due to special conditions such as large estates or greater manufacturing activity. Use in unmetered cities may be much greater, due to waste and inadequate controls. In general, water-works which account for more than 90 per cent of production through metered sales to consumers reflect good construction and efficient operation.

The United States Public Health Service, through its quality requirements for drinking water supplied by public carriers in interstate commerce,

has established standards of water quality. These standards have been accepted and adopted for the most part by all State boards of health, and all water works are required to comply with them.

The American people have grown accustomed to the liberal use of water. More families than ever before in the United States have bathrooms and washing machines. New water-using devices, such as automatic dishwashing and garbage disposal fixtures, are appearing in the kitchen in increasing numbers. Air conditioning of factories, offices, and stores, with its added demand for water, is quite common.

The average per capita water use in 10 European cities, including London, Paris, Vienna, Edinburgh, and Berlin, before World War II was 39 gallons per day; in the same number of American cities, it was 155 gallons per day. In the latter group are New York, Philadelphia, Baltimore, Chicago, and Detroit.

Personal demands of the average American city dweller may soon amount to about 200 gallons per day. Figures for certain locations in gallons per person per day are as follows:

Richmond, Virginia	128
New York City	150
Denver (month of May 1950)	200
Chicago	235
Highly industrialized cities	300 or more

The larger the city the greater is the per capita demand. Towns of 500 population have an average consumption rate of 60 gallons per day. Towns of 1,000 population use 85 gallons, 5,000 population use 135 gallons, and 5,000 to 10,000 require at least 140 gallons per person per day on the average. A few decades ago engineers figured that 100 gallons per person per day constituted a safe volume on which to base plans for water works installations. Now they are wondering if the new needs for water that keep mounting with modern conveniences can be met if they rate their new plants at 200 gallons or more per person per day.

The following table shows the per cent increase of population served, water used, and the daily per capita use, between 1940 and 1950, for seven North Carolina cities.

City	Population			Average Water Used Per Day			Gallons Per Capita Average		Gallons Per Capita Peak Based on one Mo.	
	1940	1950	% Inc.	1940	1950	% Inc.	1940	1950	1940	1950
Charlotte	130,000	167,000	28.4	8,620,000	15,150,000	75.7	66.1	91	75.5	109.5
Durham	61,000	73,500	20.6	5,940,000	8,150,000	37.2	97.2	111	111	128
Gastonia	39,500	48,200	22.4	2,195,000	4,420,000	100.1	56.5	91	65.5	109.5
Greensboro	71,900	90,000	24.2	5,560,000	8,810,000	58.5	77.5	98	88.5	112
Raleigh	56,000	70,000	25.0	4,150,000	6,850,000	65%	74	97.5	85	111.5
Winston-Salem	90,000	100,000	11.0	7,970,000	11,680,000	46.6	88.4	116.8	101	134.8
Wilmington	38,000	48,500	30.1	2,370,000	5,030,000	112.1	62.5	104	72.5	119
Totals	486,400	597,200	22.8	26,805,000	60,090,000	64.5	75.6	100.6	86.9	115.70

From the above data, it is estimated that the per capita demand for 1970 will be 170 gallons per day.

Estimated Increase of Use -- It is estimated that 330 million gallons of water were used daily during 1950 for domestic and municipal uses in the State. In the past twenty years, our population has increased 28 per cent, and the use of domestic and municipal water has increased over 75 per cent. Therefore, it is estimated that 725 million gallons will be used during 1970.

Man's activity in relation to water involves both its use and control. As his scale of living improves, he demands greater and greater supplies of water to aid in providing increased comforts. As water use increases, the control of water becomes more necessary to insure adequate supplies, abate stream pollution, protect property from flood and erosion damage, and enlarge recreational opportunities.

The uses of water are many and varied. They may be classified generally according to domestic, municipal, agricultural, industrial, recreational, and hydroelectric purposes.

Modern living has increased water usage in the home beyond the belief of forecasters of only three decades ago. It may be that a saturation point in domestic use of water has been reached, in so far as modern equipment is concerned. That is, one home that is equipped now with all of the available appliances may not be expected to have a much larger demand for water volume over the next twenty years.

The number of homes having this complete installation, however, is relatively small. As more families obtain electrical dish washers, garbage disposal units, tubs, showers, automatic washers, and full bath or two bathroom installations, the need for more water in the homes will be immensely increased. It is impossible to predict the amount of this increase. It appears, however, that the surface is barely scratched as yet in the providing of all of these facilities to all homes.

Here again, the saving of water, the proper channeling of it, and the prevention of huge losses become a major problem of public interest and concern.

An idea of the amounts of water required for various common home uses may be gained from the table below.

CAPACITY AND REQUIREMENTS OF VARIOUS WATER USES

USE	GALLONS PER MINUTE DURING PERIOD OF USE
Bath tub (bath requires about 30 gallons)	5-10
Lavatory (to fill requires about 1½ gallons)	3-5
Tank Closets (flushing takes 4 to 6 gallons)	3-5
Shower Bath (bath requires about 30 gallons)	3-5
Laundry Tub	5-10
Automatic home laundry (hot water required)	13-30
Sink (use per day, each faucet, 7 to 15 gallons)	3-10
Drinking Fountain	1-2
Lawn Sprinkling ½" hose	2-4
Lawn Sprinkling 3/4" hose	4-8
To sprinkle 100 sq. ft. of lawn (¼" of water) requires	16 gallons
To soak 100 sq. ft. of lawn (1" of water) requires	65 gallons

One of the earliest public water supply systems of this country was built at Salem, (now Winston-Salem) North Carolina, by the Moravian brotherhood; work was begun on a gravity system in 1774, and their first supply was piped in 1776.

In 1880, there were only 16 public water supply systems in the United States; by 1900, there were some 3000; and in 1948, there were more than 16,000 public water supplies, providing to almost two-thirds of this country's population their daily water requirements.

Uses in North Carolina - - In North Carolina, domestic and municipal water supplies, derived from surface water sources and from ground water sources, are about equal, surface water sources supplying 148 towns, and ground water sources, 157 towns. Throughout the Mountain Region, the Piedmont Plateau, and the western part of the Coastal Plain, water is obtained primarily from streams. In the Tidewater and Coastal areas, the supply is primarily from ground water sources.

A large portion of the water supply requirements for domestic and municipal purposes is derived from surface sources and requires purification to make it of acceptable sanitary quality. It is necessary that pollution of our streams, from which these supplies are taken, be controlled within limits compatible with its purification for domestic and municipal use.

A study of salt water intrusion in tidal waters of the Neuse and Tar-Pamlico Rivers, recently initiated under a cooperative agreement between the State of North Carolina and the Geological Survey, United States Department of the Interior, will furnish valuable information regarding the infiltration of saline river water into the ground water aquifers.

Treatment of Public Water Supplies - - North Carolina public water supplies are kept safe by water purification plants, using a wide variety, and often combinations, of treatment processes such as prechlorinization, coagulation, sedimentation, filtration, alkalization, removal of ammonia and iron, softening, and other necessary treatments. In most cases, these treatments are only necessary in connection with surface water supplies. Ground water supplies, springs and deep and shallow wells are treated when they are unsafe or contain disagreeable properties. Of the 148 surface water supplies in the State, 114 are treated, and 17 of the State's 157 ground water supplies receive treatment. The safety of these water supplies is assured by the comprehensive activities of the State Board of Health. The Sanitary Engineering Division of the State Board of Health is responsible for the development, promotion, and technical supervision of the program of environmental sanitation, and for the co-ordination of this program with those of local health departments. This division is also responsible for the enforcement of State Health laws and regulations relating to sanitation and sanitary engineering.

The State Stream Sanitation Committee, to which the State Board of Health provides administrative support, further insures the safety of our water supply by conducting pollution surveys, establishing classifications of water usage, and setting standards of quality for various uses.

Fluoridation of public water supplies in North Carolina continues to receive additional attention. Considerable interest therein is being shown by the medical and dental professions and municipal officials. During 1953 and 1954 five new projects were approved and seventeen towns started the fluoridation of their water supplies.

Serious water shortages occurred in the State during 1953 and 1954. Many of the cities and towns of the State are improving and expanding their water systems. Contracts have been let for 63 major water system improvements and 59 sewage works improvements, totaling over 19 million dollars. Since 1947, twelve towns that were without public water systems have installed adequate public water supplies.

CHAPTER IV--USE OF WATER FOR AGRICULTURE

Water Requirements -- On the farm, the concept of an adequate supply of water has changed in revolutionary manner over the last two decades. The word "adequate" no longer means hand-pumped filling of troughs twice a day, or the carrying of water from an outdoor pump to the marble-topped kitchen wash stand.

An adequate supply of water now must provide for constant washing of milking machines, for operation of bath rooms and well-equipped kitchens, for the automatic filling of stock tanks and troughs, and for pumping water to many points of use at the same time.

Rainfall, key to both underground and surface storage, thus takes on new importance, even beyond the place it has always held in the growing of crops. By construction of farm ponds, rainfall may be saved for the watering of stock in areas where automatic pumping from streams and ground sources proves impractical. Increased storage, both for general farm operations and for the farm homes, becomes the major requirement for the coming years. This increase in storage is possible when the wastage in flood seasons and the lack of control on farm lands for so many years are fully realized. Lack of water on farms, as at present in dry seasons, is not necessary if proper storage is provided.

In the farm home, the amounts of water used vary with the availability of the supply and the plumbing facilities. Amounts used in homes supplied from an outside pump have been found generally to be less than eight gallons per person per day. Use increases with the installation of a pump or faucet at the kitchen sink, and still another increase occurs with hot and cold running water. With complete plumbing facilities the consumption may reach 50 gallons per person per day.

Livestock on farms probably require more water than is used in farm homes. The consumption varies with the size and use of the stock. Average water requirements for some livestock are given in the following table.

AVERAGE LIVESTOCK WATER REQUIREMENTS

Livestock	Gallons per day per animal
Horses	10-12
Beef cattle	10-12
Dairy cattle	12.5-30
Sheep	1-1.5
Growing and fattening hogs	0.5-2
Lactating sows	5

Farm crops depend on rainfall and soil moisture as a general rule. The ability of the soil to provide sufficient moisture is very limited in some areas, and the success of farming is largely dependent upon favorable rainfall, unless irrigation is utilized.

It has been found that, to grow corn yielding 100 bushels per acre, the water required would equal an amount that would cover the ground to about 20 inches. This volume is equivalent to 543,000 gallons per acre. The growth of

good meadow requires the same amount of water through a growing season. Wheat yielding 35 bushels per acre has been found to require nearly 15 inches of water, or 407,000 gallons per acre. Where soil moisture is insufficient to meet crop demands during extended intervals between rains, the use of irrigation will prove beneficial.

Advantage of Irrigation - - Supplemental irrigation offers possibilities for increases in crop yields on light textured soils even when moisture conditions throughout the growing season are above average. These soils have a low available waterholding capacity. They are, however, open enough to allow good aeration. Some supplemental irrigation to medium textured soils may be an insurance against a great reduction in yield during extreme dry periods. The value of irrigation on the heavier, poorly-aerated soils seems questionable. Factors other than water appear to be primarily responsible for limited production on these soils.

The greatest use for fresh water in the United States is for irrigation. In 1950, 26 million acres of irrigated land received about 50 per cent of all fresh-water withdrawals. It is estimated that irrigation accounts for over 80 per cent of the total consumptive depletion of all water uses. Approximately 18 per cent of the withdrawals of fresh water for irrigation is obtained from wells, some with artesian flows but most with pumping. In California alone, the gross total pumpage in 1950 was 10 million acre-feet, which is about 40 per cent of the total pumpage in the United States.

Use for Irrigation Throughout the United States - - Until recently we thought of this use of water as being something limited to the western part of the United States. A large part of the irrigation in the country has been in the arid sections west of the 100th meridian. At the present time there is a drive in the building of giant dams in the western states, with billions of dollars involved. At the very most the irrigationists, dreaming and speculating on what they can do with dams, canals and irrigation ditches, hope to supply crop water to no more than 19,000,000 acres additional to the 20,000,000 acres which were being irrigated in 1950. If it takes an average of 2 acre feet of water to grow crops, the added annual demand on water for western irrigation will be 38,000,000 acre feet, which amounts to approximately 1,318,432 billion gallons.

Until recent years practically all agriculturists east of the 100th meridian, from those engaged in the most extensive types of husbandry to those who grow vegetables and fruits, put their trust in getting sufficient rain at the right time to mature crops. Whether there have been increasing areas and times of drought to stimulate changes, or men tampering with drainage and our mounting demand on ground water have lowered the water table, or whether there are other factors, the East has discovered irrigation.

Much of the irrigation in the East has been accomplished through the use of overhead sprinkler systems. This practice is in contrast to western irrigation methods by which water is led to the fields through canals and ditches, and spread across the surface of the fields or allowed to send little rivulets down beside the rows of planted crops.

The difference in many sections east of the great plains between a good crop and one blighted by drought may be a matter of a few days or even a week or two when the skies do not deliver rain. Irrigation can insure a good harvest. If such irrigation amounts to the spreading of one acre foot of water on a 10-acre field, 3,258,506 gallons of water would be used. This estimate

is not considered to be excessive. Some crops require about two acre feet, and intensive types of crops require about four acre feet, slightly over 13,000,000 gallons for a 10-acre field, when a dry spell occurs at the height of a growing season.

One might think that, if water is spread on the land by sprinklers, most of it would return into ground supplies. Actually, most of it is drawn out of the surface soil by plant roots or evaporated from the soil, to become moisture content in the air and carried away.

As the population increases, the amount of cultivated land available does not increase in proportion, and each acre must produce more certainly and in greater abundance. Irrigation is a major aid to increasing crops from areas in cultivation. Since the increasing demand for food by more people insures better prices, the farmer is going to resort to irrigation as a matter of personal profit. The quality and quantity of crops are increased by irrigation. These increases cause additions to profits, which in turn lead to more use of water for irrigation purposes.

Another phase of the sprinkler type of irrigation is developing in the West, where farmers are alert to any advance in irrigation methods. The type of irrigation that has been standard there, which consists of leading the water to fields and spreading it or running it down between row crops, is not possible unless the land is accurately graded. It must be nearly level, so that water will flow slowly and will soak into the ground. This leveling-off requires a considerable outlay of money. There may be spots in a field where the top soil must be removed from a little hump, the subsoil cut down, and the fertile soil spread back where the high spot had been. This leveling-off increases capital investment.

The use of the sprinklers side-steps this leveling-off cost. The spray application of water can moisten a hillside that would be too steep to plow with any hope of retaining the topsoil if little irrigation ditches ran so fast that they continually cut away soil. The sprinkler can moisten a slope gently, avoiding erosion and growing crops that need quantities of water where the old ditch-type systems could not succeed.

Use for Irrigation in the East - - Irrigation increased vastly in Indiana in the summer of 1954, the first time, in fact, that it has gained real status as a factor in crop growing. It is spotted in many sections. This new demand for water has caused the Indiana Flood Control and Water Resources Commission to appoint a special committee to study the problem. Their concern is the same as that in the Southeast: Are new statutes needed?

Texas, as always, needs rain. It is certain that the 1955 Legislature will be under pressure for enactment of an effective program of water resource development. A Texas Water Resources Committee has been engaged in drawing up recommendations for water laws.

In irrigated states of the Midwest and West, the general situation was that there was sufficient water to handle crops, in the summer of 1954. Storage was drawn way down, however, indicating bad times ahead for crops in the summer of 1955.

In Ohio, crops generally received ample rainfall in 1954. Ground water tables, however, were at a record low, varying from six inches to three feet and six inches below the 1953 average, according to the Ohio Water Conservation Committee. Conditions were expected were expected to worsen by early fall. The Governor's 100-member water study committee was seeking long-range solutions to the problem and new laws and recommendations for conserving and improving water supplies.

As farmers have turned more and more to the use of ground water resources, including use for irrigation purposes, conflict has entered into this field. One of the difficulties in regulating ground water, so that it may best serve the many uses thereof, lies in the uncertainties regarding where it comes from and where it goes. It may be in a stationary pool, with no overflow under the earth, in which case what is withdrawn affects only those holding property directly above it. It may be percolating or actually growing in underground streams. Or it may be in an artesian basin, where the first wells drilled spout under pressure but fail to flow as more and more wells are put down.

More and more southern farmers have realized, and will increasingly realize, that it is cheaper to irrigate than to lose crops to drought. Irrigation, supplemental to dwindling water supplies, is now generally regarded as the coming thing for eastern agricultural areas. There is nothing new about the idea. Wide use, however, of the idea of supplemental irrigation is new, and droughts like the one which settled on the Southeast in the summer of 1954 will see to it that the idea grows.

Experts have told South Carolina farmers that irrigation is the answer to many of their problems. It can take a big chunk of the risk out of farming where ten to fourteen days without rain can kill or cripple a crop. In Virginia, a legislator has called irrigation "The Missing Link in Maximum Production on Southern Farms".

Supplemental irrigation looms large as a future use of water in areas besides the Southeast. Irrigation of high value crops is fairly common in Massachusetts, Connecticutt, Rhode Island, New York, New Jersey, Delaware, and Florida. It is also a subject which has been brought up with grave concern in Indiana and Ohio.

At an irrigation conference in Raleigh on August 9, 1954, sponsored by the Progressive Farmer and attended by farmers and representatives of the State Department of Agriculture, State Department of Conservation and Development, North Carolina State College, the State Agriculture Extension Service, the Governor's Advisory Committee on Water Resources, the Farm Bureau, the Eastern North Carolina Farmer, the U. S. Farmers Home Administration, and the U. S. Soil Conservation Service, it was generally agreed that the use of water in North Carolina for irrigation is increasing greatly, that a survey of North Carolina waters should be made with a view to their conservation, that legislation covering the whole water problem is needed, and that owners of land on the banks of streams must be protected against the construction of dams or other damaging use of water by owners of land above them. Some of the statements made at this conference follow.

North Carolina farmers are not afraid of expense incurred in irrigation

provided there is a justifiable reason for the expense and they are convinced that it is more expensive not to irrigate. The best type of irrigation equipment consists of portable pumps and revolving sprinklers. The number of acres of tobacco irrigated in North Carolina increased from 500 acres in 1951 to 6000 acres in 1954. Some of the mistakes being made by farmers in purchasing irrigation equipment are (1) purchase of system without adequate supply of water, (2) purchase of system not correctly designed, and (3) improper diagnosis of the situation, resulting in not making the best use of water without irrigation. There is a need for understanding of irrigation on several levels, returns from investments, costs, engineering, knowledge of root habits of plants, changes in soil content, and time of demands for water by various plants. Irrigation is important because (1) the cropland per person is decreasing, (2) income per capita is low, and (3) control programs have caused a decline in acres available per person. High pressure salesmanship in connection with irrigation will get farmers into trouble. More labor and a more skilled type of labor are needed for irrigation. Crop yield is better with irrigation, and the quality of irrigated crops is near the top of the market. Irrigation of cantaloupes and corn brings high profits. We can do better planting and have a better stand where we use irrigation. How we should use water is important in order to make farming more profitable. Farmers are demanding information. Everybody is irrigation conscious. Very few know anything in a practical way. Irrigation has decreased the nicotine content, and increased the sugar content, of tobacco, thereby increasing its quality and the profit derived therefrom. More tobacco is damaged by too much water than by too little water. A flood of applications for loans to buy irrigation equipment has been received. Farmers have bought pipe which they cannot use and sprinklers which are too large or too small. The important thing is to inform the farmers regarding the mistakes which they should not make.

Characteristics of Soils in North Carolina - - Soils are the product of the forces of climate and organisms acting on geological material, known as soil parent material. The effect of these forces are modified by the topography of the land and time. Although there is similarity in some of the geological materials of the Piedmont and Mountain regions, the soils of the Mountain Region differ from those of the Piedmont Region mainly because of climatic difference. Soils are composed of a surface layer, known as surface soil, and a layer beneath, known as subsoil.

In general most of the soils of the upper Coastal Plain are considered deep, or more than 36 inches over the parent geological materials. They are coarse and sandy, having been formed from geological materials of high sand content and low in silt and clay. The surface soils are sand or sandy loam. The subsoils are sandy loams to sandy clays, of yellow, brown, or red color. Most soils of the sand-hills regions are sand to a depth of several feet. In the middle Coastal Plain the soils are deep, having coarse to medium-textured surface soils and medium to medium-fine subsoils. In the Tidewater Region most soils are deep and have medium to fine texture. Silt loam surface soils, and silty clay loam to clay loam subsoils, are common because of the large areas of fine textured geological materials. Due to poor drainage in this region both surface soils and subsoils are of dark color.

In the Piedmont Region soils are in general more than 36 inches over rocks. Most of the subsoils are clay, the color varying from red to yellow depending on the soil parent material, with the exception of a few small areas of poor drainage.

In the Mountain Region the soils are shallower than in the Piedmont Region, usually less than 36 inches over rocks, because of slower weathering in the cooler climate and steeper slopes. Most of the subsoils are loam or clay-loam, with colors from brown to reddish brown. The surface soils have a loam texture, and in many places rock is present on the surface and in the soils.

The various soil types are made up of differently sized soil particles. The light, sandy soils are made up of relatively large particles. Consequently, there are rather large spaces between these particles which are referred to as water reservoirs in the soil mass. There are fewer of these reservoirs in the loam-to-clay-loam soils, which are made up of finer particles. The smaller the particles, the greater is the number of spaces between the particles. The ability of a soil to hold water is based on the surface area of the soil particles, the number of spaces, and the surface tension, or the attraction of the water to the soil particle surface. The less water there is in the soil, the tighter it is held. Surface tension, or the attraction of a film of water around the soil particles, results in a film of water around the soil particles that cannot be used by the plant.

The following tables will give detailed information. Table 1 shows a rough estimate of peak water use and loss per day of average crop land in the three major regions of the State. This table is based on the general average of soil holding capacity in the first 18 inches, which is taken to be 1.5 inches. The results of extensive study show that for average conditions irrigation should start when the moisture content of the soil is about 50% of the soils-holding capacity. As an example, from Table 1, Coastal Plain and Piedmont Region, the crop in June would require irrigation each $4\frac{1}{2}$ days.

Table 2 shows some of the characteristic soils of the three regions, and gives the representative moisture-holding capacity and rate of soil absorption in the upper 18 inches of soils. It is apparent from study of this table that a great variety of problems need to be worked out so that each soil type in different localities will have a properly designed system of irrigation.

Table 3, used in conjunction with Tables 1 and 2, shows the frequency of irrigation that would be necessary with different types of soils and in different regions.

Table 4 indicates depth of moisture replacement and peak moisture use rates, showing the recommendations for various crops in the three major regions of the State. This table, used in conjunction with Tables 1, 2, and 3, will greatly aid in fitting the design of irrigation systems to fit the particular needs of crops in different localities.

Table 5 shows the state-wide increase in the use of irrigation in the past 10 years. This increase has not progressed regularly for the past ten years. The experience of the need for irrigation within the last four years, when losses due to seasonable and local droughts have been increasing, has accelerated the installation of irrigation systems.

TABLE I

THE PEAK WATER USE AND LOSS PER DAY
IS ROUGHLY ESTIMATED AS FOLLOWS

Coastal Plain & Piedmont	Month	Mountain Area
0.11 of an inch per day in -	April -	
0.14 of an inch per day in -	May -	0.12
0.17 of an inch per day in -	June -	0.15
0.16 of an inch per day in -	July -	0.14
0.14 of an inch per day in -	August -	0.12

TABLE 2

SOILS GENERALLY USED FOR TOBACCO IN NORTH CAROLINA AND SOME SOIL CHARACTERISTICS RELATED TO RATE OF WATER ABSORPTION AND HOLDING CAPACITY

Drainage	Soil Description	Type	Organic Matter	Max. Available Moisture Holding capacity in upper 18 Inches	Rate Soil Absorbs Water Per Hour
COASTAL PLAIN					
Very well drained	Deep light texture sandy soil (sand subsoil)	Lakeland	very low	1.0	.90
Well drained	Medium sandy loam soil sandy clay loam subsoil	Norfolk	low	S.L. 1.5 Loamy Sand 1.1	.55 .65
Well drained more sloping than Norfolk	Medium sandy loam soil (brownish sandy clay loam subsoil)	Ruston	low	1.6	.55
Moderately well drained	Medium sandy loam soil (sandy clay subsoil) Mottled in lower subsoil	Goldsboro	higher than Norfolk	1.5	.55
Imperfectly drained	Medium sandy loam soil (sandy clay subsoil)	Dunbar	medium	1.7	.30
Imperfectly drained	Medium sandy loam soil (sandy clay subsoil)	Lynchburg	medium to low	1.5	.55
Moderately well drained	Yellowish sandy (with gray mottled subsoil)	Klej	low	1.1	.70
PIEDMONT					
Well drained	Sandy soil with yellowish clay subsoil	Durham	low	1.6	.40
Moderately well drained	Sandy soil with reddish clay subsoil	Appling	low	1.6	.40
Moderately well drained	Sandy loam (yellow-brown clay subsoil)	Helena	low	1.8	.25
Moderately well drained	Similar to Helena but thinner top and subsoil	Wilkes	low	1.6	.25
Well drained	Red clay to pink top-soil - Red clay subsoil (eroded sandy top)	Cecil Clay Loan	low	2.3	.25
MOUNTAIN AREA					
Well drained	Deep loams - bottom and 2nd bottom	Congare	medium	F.S.L. 2.0 Silt L. 2.2	.40 .25
		Tusquitte		2.7	.50
Very well drained	Thin loams and clay loams - upland	Halewood		2.2	.40
		Hayesville	low	2.2	.40

NOTE: Compare your soil to the one most like yours, described above. Note the approximate maximum water holding capacity. Compare the selected water holding capacity that you think is representative of your soil to the corresponding available moisture holding capacity shown in Table 2. Then follow across the table to the right and note the irrigation frequency in days and the suggested amount of water to apply per application.

TABLE 3

MOISTURE USE AND REPLACEMENT RATE BASED ON HOLDING CAPACITY OF THE SOIL IN THE UPPER 18 INCHES

COASTAL PLAINS AND PIEDMONT AREAS

Peak Moisture Use Per Day	Maximum-Available Moisture Holding Capacity-Inches	Moisture to be Replaced Each Irrigation -inches-	Irrigation Frequency -Days-	Application *Amount Inches
0.16 inches	.90-1.45	.64	4 - 5	.7 - 1.0
	1.45-1.75	.80	5 - 6	.9 - 1.2
	1.75-2.10	.96	6 - 7	1.2 - 1.4
	2.10-2.40	1.12	7 - 8	1.4 - 1.6
MOUNTAIN AREA				
0.14	1.80 - 2.10	.98	7 - 8	1.2 - 1.4
	2.10 - 2.40	1.12	8 - 9	1.4 - 1.6
	2.40 - 2.70	1.26	9 -10	1.6 - 1.8

* Irrigations considered 75% efficient; therefore a one-inch irrigation will replace 0.75 inch of moisture. NOTE: Though 18 inches is used here as being the area in which most of the tobacco roots are located, it is recognized that this may vary widely on different soil types.

DEFINITION

1 acre inch = 27,000 gallons

1 acre foot = 12 acre inch

1 acre inch per hour = 450 gallons per minute

TABLE 4
RECOMMENDED DEPTH OF MOISTURE REPLACEMENT
AND
RECOMMENDED PEAK MOISTURE USE RATE FOR DESIGN PURPOSES

Crop	Depth of Moisture Replacement (Feet)	Recommended Peak Moisture use Rate For Design Purposes	
		Coastal Plain & Piedmont Plateau (Inches)	Mountain Area (Inches)
Alfalfa	2.5	.24	.22
Annual & Perennial Flowers	1.0	.14	.12
Azaleas & Camellias	2.0	.18	.14
Cotton	2.5	.20	.18
Corn, Field	2.5	.22	.20
Gladioli	1.0	.14	.12
Improved Pasture	1.5	.24	.22
Mixed Hay	1.5	.24	.22
Nursery Crops - 1st yr.	1.0	.16	.14
Nursery Crops - 2nd yr.	2.0	.18	.16
Orchards, bare	3.0	.20	.18
Orchards, cover	3.0	.24	.22
Peanuts	2.0	.18	.16
Peas, field	1.5	.18	.16
Potatoes, Irish	1.5	.20	.18
Potatoes, Sweet	2.0	.22	.20
Small Grain	2.0	.18	.16
Soybeans	2.0	.18	.16
Strawberries	1.0	.14	.12
Tobacco	1.5	.18	.16
Vineyards, cultivated	3.0	.18	.16
Vegetables, Group 1	1.0	.14	.12
Vegetables, Group 2	1.5	.14	.12
Vegetables, Group 3	1.5	.18	.16
Vegetables, Group 4	2.0	.18	.16

Vegetables, Group 1

- Kale
- Lettuce
- Mustard
- Onions
- Spinach

Vegetables, Group 2

- Beans, snap
- Beets
- Broccoli
- Cabbage
- Cauliflower
- Carrots
- Collards
- Peas, garden
- Peppers
- Turnips
- Rutabagas

Vegetables, Group 3

- Bean, lima
- Cucumbers
- Tomatoes

Vegetables, Group 4

- Asparagus
- Cantaloupes
- Corn, sweet
- Eggplant
- Okra
- Watermelon

TABLE 5

IRRIGATION INFORMATION

STATE OF NORTH CAROLINA
1954

1. Number of farm irrigation systems in the state now 1500, 10 years ago 30. What percentage now of flood type 5%, sprinkler type 99.5%.

2. Number of acres being irrigated in state now 17850, 10 years ago 400.

3. Crops and acres being irrigated:

Crop	Acres now	Acres 10 years ago
Cotton	50	0
Corn	300	0
Pastures	3000	0
Commercial truck	3000	150
Tobacco	10,000	0
Rice	0	0
Fruits	1000	100
Other	500	150

Depth of Moisture Replacement and Peak Moisture Use - - Each soil has a characteristic absorption rate and storage capacity, as has been outlined in the proceeding general description of soils and regions in which they occur. It is apparent that each region in general will present a different irrigation problem. In addition to this variation, there will be different regional problems that will be affected by topography, precipitation, climate, surface and underground water supply, and demands of industries, municipalities, and other users. The crop to be irrigated is of prime consideration.

There are several basic principles that must be considered for a clear understanding of the absorption rate and water holding capacities of various soils. This can be best understood by considering the soil types by areas, Coastal Plain, Piedmont, and Mountain.

Planning Irrigation Projects - - No irrigation project can prove successful if the soil is not suitable, or cannot be made suitable, for continuous profitable crop production. Many failures of early irrigation developments resulted from improper or insufficient considerations of soil problems. Soil conditions have important influences on the selection of crops, choice of farm practices, planning of farm distribution systems, and methods of applying water. Consequently, irrigation soils require thorough investigation and attention, not only in working out plans for new projects but also in maintaining profitable crop yields on existing projects.

Detailed surveys of soil conditions on areas to be supplied with water are needed in planning new irrigation projects, and in planning extensions of existing projects. When soil surveys have been made for the area under consideration, all survey reports should be analyzed before proceeding with project development. Soil surveys are conducted in North Carolina by the United States Department of Agriculture, in cooperation with the North Carolina Department of Agriculture, and are made available in publications by counties.

The quality of the source water for irrigation, in a long term sense, is of paramount importance. There have been instances where once fertile land has been abandoned due to irrigation with unsuitable water. Continued successful and profitable agriculture by long-time irrigation is contingent upon keeping down the salt content of the land. Doubtless more irrigated lands have been abandoned through the ages because of increased salinity of the soils than because of failures in the quantities of water and the combination of all other possible causes.

The return water from irrigation, by seepage and runoff, is always of poorer quality than the water that is applied to the land, the degree of impairment varying with the amount and kind of soluable matter in the soil and in the deeper strata. The subsequent use for irrigation of the return water increases its chemical pollution with each use until, in extreme instances, it is so heavily loaded with salts that it will not promote plant growth. The more highly the water is mineralized at its source, the less the irrigated lands have been bleached, and the poorer the drainage, both natural and artificial, the more pressing will be the problems related to the quality of the water and the greater will be the danger of short-lived irrigation.

Irrigation Equipment - - Irrigation is the artificial application of water to the soil, supplementing rainfall, chiefly for the purpose of maturing crops or increasing their yields. It may include the occasional sprinkling of a city lawn or flower garden during a brief dry spell, or the supplying of nearly all of the water required by the crops on a large farm in a region of typically low rainfall.

There has been an increase in the demand for farm crops in general as well as a shift towards the things typically produced under irrigation, pasture, grain, cotton, tobacco, vegetables for dehydration and canning, and many others. As a result, experienced irrigation farmers are being pressed for greater and greater production with less and less labor and equipment available, and new men and women are entering the irrigation field in increasing numbers. Both groups should find practical help in solving new problems.

There are several types of sprinkling devices in use. The most commonly used type in North Carolina is the rotating sprinkler heads. These heads are mounted by means of riser pipes of different lengths on light-weight, quick-coupling pipe. This pipe usually comes in 20-foot lengths. Risers may be less than two feet high for use on low-growing crops or to keep the water under the trees in an orchard, or as much as 30 feet high to throw the spray over the top of the trees. Risers and sprinkler heads may be attached to each second or third length of pipe. These sprinklers operate on pressures from as low as 15 to over 100 pounds per square inch. Sprinklers, operating at low pressure and throwing water out at a low angle to stay below most of the branches, are sometimes used in orchards. Rotating sprinklers at the usual spacings will apply water at rates equivalent to from one-tenth to two inches of rain per hour.

Both galvanized steel and aluminum pipe are used for the portable lines. The latter is more popular because of its light weight. There are many types of quick-action coupling. The minimum requirements for a satisfactory coupling are: (1) It must not leak when subjected to the operating pressure. (2) It must be so designed that it can be disconnected and connected by the operator when he is at the center of a 20 or 40 foot section. In other words, he must not be required to walk to the coupling either to unfasten or fasten it. (3) It must be sufficiently flexible to allow the laying of a line over moderately rough ground without undue strain on the pipe or leakage at the joints. (4) It must be light, in weight. (5) It must provide for keeping the riser upright or the center line of holes in perforated pipe directly at thetop of the pipe as laid. (6) It must be sufficiently rugged to withstand hard usage. (7) It must permit the water to drain out quickly when the pressure is released.

On most family-size farms in North Carolina irrigation is not handled as a full time job, because most of those now in operation cover relatively small areas. Even on larger farms irrigators seldom work regular hours, and it is difficult to say just how many hours are required to irrigate a given area. On row crops on steep or rough land one cubic foot per second of water may require the full time of one man. Since this stream is equal to one acre-inch per hour, a 4 inch application (about the minimum under such conditions) will require 4 man hours per acre.

The rotating sprinkler system most nearly imitates natural rain fall. Sprinklers, when properly designed and operated, have these advantages:

(1) Irrigation can be accomplished without danger of erosion. Steeper land can be irrigated by sprinklers than by other methods.

(2) Water can be spread fairly evenly. Such spreading is especially important on sandy soils.

(3) Not much water is wasted.

(4) There is little or no need for land leveling. Use of sprinklers makes it possible to irrigate shallow soils where leveling might be out of the question.

(5) The entire field can be used for crops.

Disadvantages of Sprinklers are as follows: (1) The first cost is high, and sprinkler equipment wears out and must be replaced.
(2) Wind may cause uneven distribution of water.

(3) A constant supply of water is necessary to make a sprinkler system work efficiently. The water must be clean or the nozzles will clog.

(4) Power is required. Sprinklers need from 15 to 100 pounds pressure per square inch.

(5) When corn gets high, long extensions are needed to raise the sprinkler heads. These extensions must often be braced. It is not easy to move pipe from one setting to another in high corn.

There are a number of different costs associated with irrigating any crop. Some of these costs are:
(1) Making available a water supply.

(2) Initial cost of an irrigation system.

(3) Operation and upkeep cost.

(4) Labor.

The cost of a water supply will vary from one farm to another. On many farms there is already available a farm pond of sufficient capacity from which to irrigate sizeable acreages. On other farms there are running streams which would provide sufficient water for irrigating large acreages. The cost of providing a water supply in such cases would be negligible. On the other hand, if special consideration had to be given to providing a water supply, the cost would vary according to the ease with which the supply could be made available. So many variations are encountered from to farm that it is practically impossible to set up a criterion on which to base the cost of providing ample supplies of water. The range of cost varies from zero in some cases to figures beyond economic reason in other cases.

The initial cost of an irrigation system is influenced by the following factors:
(1) Size, shape, and arrangement of fields.
(2) Distance between the source of water and the fields to be irrigated.
(3) Size of a system purchased when compared to size area to be irrigated.
(4) Elevation difference between source of water and the field to be irrigated.

An irrigation system should be an integrated unit with both pump and power plant selected for the job at hand. An article in the Progressive Farmer in February 1953 cites the cost of a small unit, minus power plant, suitable for irrigation of up to 20 acres, as follows:

3-by 2½ inch pump, with belt and priming device	$175.
Four inch by 20 ft. aluminum suction pipe with elbow and strainer	50.
1000 feet of 4 inch aluminum portable pipe	950.
500 feet of 3 inch aluminum pipe	350.
Elbow, cap and risers	25.
10 rotating sprinklers	60.
Total	$1610.

The reason that no power unit is included in the above costs is that most farmers use their tractor as a power unit. These costs amount to about $80. per acre, which is typical for the size system without its own power unit. Small systems may run twice as much per acre, and large systems half as much. The most effective way to reduce per acre cost of a system is to pump more hours per week. In this way more acres can be irrigated with the same system. The length of pumping is also very important. It may be noted that the cost of a 4 inch main is over half of the total cost. A source of water nearer the field would accomplish considerable savings in first cost and pumping cost.

Aside from engine and sprinklers, little wearing out occurs in an irrigation system. Sprinklers, used for irrigation, should last about five years. Rubber suction and discharge hoses may last only five or six years if left exposed. Aluminum pipe used in place of rubber hose should last at least twenty years, as will properly cared for portable pipe. A good pump should also last twenty years if properly serviced.

In addition to the encouraging economic aspects indicated above, an irrigation system on hand when needed can help considerably in establishing a uniform and excellent crop which should have greater value than a crop for the production of which irrigation is not used.

Value of Irrigation - - The question is arising as to why farmers, and fewer of them, use more water on fewer acres. The answer to this question lies in changes in modern farming. A part of the answer comprises the shift from staple crops like cotton and tobacco to other types of agriculture. Increasingly, dairy and beef cattle, truck farming, poultry, and orchards make up a larger and larger part of farm production. More cattle mean more water. Cattle drink 15 to 25 gallons of water daily. A flock of 1000 chickens needs 50 gallons of water daily.

Another part of the answer is found in the manner in which the modern farmer and his family live. The farm home, like the city home, is using more household appliances and conveniences. These additions require more water. In fact, the more refined and convenient our way of living, the more we depend on larger supplies of water.

Irrigation involves the newest and largest use of water on the farm. The practice of irrigation, which only recently came into use in North Carolina,

has demonstrated such increases in production that rapid expansion of irrigation on farms in the State may be expected. Agricultural leaders have termed this "man-made rainfall" the new frontier in farming. Irrigation is the newest development in the long line of advances in agriculture. Other such advances, including better methods of breeding animals, better fertilizes, new seed varieties, and more and better farm machinery have increased yields per acre, and have made it possible for fewer farmers to produce food for increasing non-farm population.

The farmer invests heavily in seeds, fertilizer, insecticides, machinery, and labor. Yet lack of rain at critical stages of the crop season may ruin his investment. Many farmers are now convinced that the extra investment in bringing water to their crops can bring greater returns and reduce the risks of damage from drought.

Test reports show the value of irrigation on pasture, row crops, and truck crops as follows:

Increase in yield due to irrigation	Amt. of irrigation water applied	Approx. gross returns	Cost of irrigation	Approx. net return
Cotton: 1953				
655 lb/acre seed cotton	2.6"	$91.65	$9.10	$82.55
300 lb/acre seed cotton	1.2"	42.00	4.20	37.80
592 lb/acre seed cotton	3.8"	82.84	13.30	69.54
Avg.				
516 lb/acre seed cotton	2.5"	72.16	8.87	63.30
Field Corn: 1952				
35 bu/acre	2.7"	59.40	9.45	49.95
50 bu/acre	4.5"	87.30	15.75	71.55
64 bu/acre	7.5"	111.75	26.25	85.50
Avg.				
49 bu/acre	4.9"	86.15	17.15	69.00
Tobacco:				
356 lb/acre 1953	3.4"	202.98	11.90	191.08
499 lb/acre 1952	4.0"	380.00	14.00	366.00
Avg.				
428 lb/acre	3.7"	291.49	12.95	278.54
Pastures:				
2500 lb/acre 1951 D.M.	8.6"	93.74	30.10	63.64
2770 lb/acre 1951 D.M.	8.5"	103.70	29.75	73.95
Avg. lb/acre Dry Matter	8.6"	98.72	29.93	68.80

It is also reported that the quality of the crop was improved in every crop studied. Irrigation produced longer staple cotton, higher grade corn, and pasture higher in protein, with greatly improved grazing throughout the year. The value of irrigation on truck and fruit crops is widely known and accepted.

Studies of irrigation, while preliminary, have been in progress since 1946. These studies indicate the tremendous value of irrigation in increasing farm production. Irrigated pastures mean more than just increased yields. With

water when he wants it, the farmer can come closer to his goal of year-round pastures. This goal means greater production as well as less time and expense in making and storing hay.

Experiments in other southern states confirm the above statements. Florida reported four times as much beef produced per acre of irrigated pasture as on the same type of pasture without irrigation. In Virginia irrigation jumped potatoe yields from 60 bags to between 200 and 300 bags per acre.

Need for Legislation - - Many North Carolina farmers have reacted in the manner which might be expected. More and more of them are studying this new way of farming, and are buying pumps and pipes for irrigation. Such action is resulting in more demands on rivers and streams in North Carolina and is raising questions regarding water rights. A breakdown of water used daily in the United States in 1950 follows:

	Billion Gallons
Irrigation	88 fresh
Industrial	65 fresh
Industrial	15 salt
Municipal	9 fresh
Rural	8 fresh

This breakdown evidences the statement previously made that the farmer is the largest user of water.

Another phase of the farmer's water-use problem is that of storage. This problem is becoming more acute each year. Power companies have been the chief builders of dams in the State, storing water to use for generating electricity. Consideration should be given to pooling funds for construction of dams on a smaller scale. South Carolina farmers on their own lands have built more than 5000 storage ponds as a start toward better storage and more evenly distributed water supplies for irrigation projects.

Are farmers on safe ground legally in undertaking joint storage for irrigation projects? Can water be diverted from a stream in periods of peak flow into storage ponds? Legislation which will provide answers to these and other questions regarding water rights which are arising, appears to be necessary. A sound legal foundation, on which to build a pattern of wise, just and efficient water-use is needed.

Perhaps the problem of storage, better than any other one factor, spotlights the dilemma in which our seasonal variation in rainfall leaves us. With too much rainfall, the State suffers from erosion, floods, and waterlogged lands. Better physical means to store this surplus for use for irrigation during droughts should be provided. With too little rainfall, competition for water becomes acute. Legislation which will determine whose claim to water is best, and what share each user should get, is required.

CHAPTER V - - USE OF WATER FOR INDUSTRIAL PURPOSES

General Water Requirements - - In every field of manufacturing there is a demand for water. In past years a company, looking for the location of a new plant, gave first consideration to available raw materials, such as ore, wood, and fiber, and transportation facilities. More and more the factor determining the location of a new industry is water supply.

Clear water is required by most industries. Clear water is not, however, good water for many industries, the water for which must meet certain standards of hardness, alkalinity, and corrosiveness. Some processes are so exact that even minute quantities of some chemicals may upset the entire sequence of production. Water that is clear and appears to be good water may be the carrier of a content of dissolved chemicals sufficient to render the water unusable. In the brewing industry, dissolved iron is totally taboo, alkalinity must be low, and sometimes calcium sulphate must be added to obtain proper conditions for processing the mash.

Reasons for Use of Ground Water - - There are three major reasons for an industry to seek and use ground water rather than surface flow. One is the degree to which surface waters that were once good and usable have been fouled and damaged. Even though a river flow might be acceptable for a certain industry at the time its plant was built, another industry could locate upstream and its wastes, if allowed to flow into the river without proper treatment, would make the water unusable.

A second reason for using ground water is that nature has already filtered it. Surface water may fluctuate in chemical content; ground water remains more nearly constant.

Finally, temperature of the water needed by an industrial plant is an important factor, and ground water temperatures vary only a few degrees through the seasons while surface water temperatures may fluctuate many degrees. Generally ground water is cool, and a large part of industrial water is used for cooling purposes.

Effect of Over-use of Ground Water - - Many of the more serious examples of water shortages have occurred where industries expand and overuse underground supplies by sinking wells within a limited area and pumping beyond the rate of recharge. At Louisville, Kentucky, World War II stepped up terrifically the output of the distilleries making alcohol and the operations for producing synthetic rubber. The pull on the water supply jumped from 37,000,000 gallons per day to 75,000,000 gallons per day. The installations were undertaken without previously having a survey made by the Ground Water Division of the U. S. Geological Survey, which would have avoided what happened. A survey, made too late, mapped the area of the ground water supply, determined the permeability of the strata through which the recharge had to come in, and found that the recharge rate was about 40,000,000 gallons per day. The industries had to act rapidly to keep in operation. Water was recirculated and reused instead of being used once and released. Cooling towers were installed to reduce loss by evaporation. Some industries relocated their wells closer to the river bank, others pumped water back into the ground reservoir to be reused again as it filtered from recharge wells to the supply wells, and still others bought water from the city to supplement existing wells. These measures pulled the pumpage from wells down to about 45,000,000 gallons per day, not too far from the recharge rate, and cost about $5,000,000. The U. S. Geological Survey

found that, if the study had been made before the installations' plants were constructed, locations for wells along the Ohio River could have been found that would have supplied several hundred million gallons of good, clear ground water per day. The study would have avoided a large part of the cost of $5,000,000 for measures which reduced the rate of pumping to approximately the recharge rate.

Need for Water-Supply Planning - - The experience of industry in many locations with water shortages has brought sharp realization of the need for determining adequacy and quality of water supply before large investments are made in plants. The viewpoint of the past, taking for granted that there was plenty of water, has had to be discarded. Industry tends to concentrate because of supply, shipping, power, and other available services. When it groups together and begins using a water supply that cannot deliver sufficient quantities for all demands, industry gets in trouble. By spacing, spreading out, and decentralizing, water sources generally can be found which will supply industry without shortages.

Where industries have already been located, plants enlarged or supplemented, and water requirements have greatly increased, somewhat extreme and ingenious measures have been taken. The celanese plant at Bishop, Texas, reduced its demand on the water resource, from which it got its supply, from 230,000,000 gallons to only 4,000,000 gallons daily by installing a big cooling tower, through which water could be passed after each temperature-reducing circuit and which allowed the water to be reused fifty times before it was discharged as waste flow. The Southland Paper Mills at Lufkin, Texas, cool off the water used to keep bearings from heating and reuse 3,000,000 gallons daily, getting back about 96 per cent of the water in each recirculation. Even with what the installation cost for recooling the water, the cost for this water is only about two-thirds of what the company has to pay for water, brought in from the source of supply. Some use of sea water has been made in industrial purposes. The fresh water is kept in a closed circuit. There is no appreciable loss of the fresh water in a circuit cooled by volumes of sea water. The outflow from sewage plants is also being used for cooling purposes. When sewage is fully processed and the outflow is actually fit to drink from the standpoint of being free from disease-carrying organisms or other harmful substance, it is good water for cooling, even though the thought of its being drinkable is repulsive.

In all of this reaching after usable water, industry accents the need for all possible planning to obtain the fullest use of the available water. It is also showing the way to use, reuse, and again reuse water. There is, nevertheless, the tremendous requirement of having usable water available, if industry is to keep on expanding and its products are to contribute increasingly to better living. Among the industries, oil refining stands first in the water-volume demanded. Metal working is second, and paper manufacturing, chemical production, distilling, and rubber production are next in line. Office buildings, requiring water for air conditioning and refrigeration, come next. Then follow food processing, ice making and cold storage, meat packing, brewing, railroads, and the dairy industry.

There should be borne in mind the essential fact that water in tremendous volume is constantly serving industry, and major consideration should be given to insuring adequate supplies of good water for such uses in the future. Industry itself, recognizing the vital requirement of good water, is driving with all of its best resources to make better and better use of the water available. From this action there is good reason to hope that this trend will be a considerable force in cleaning up those streams heretofore fouled by industry.

Survey of Water Use in Industry - - The following is taken from a survey of water use in industry by the National Association of Manufacturers and the Conservation Foundation, published in December 1950.

Water is one of the most abundant of natural resources. Yet, with such a tremendous supply, man has frequently been unable to use this resource to his full advantage.

The problem of water in our society has in recent years become the subject of much public discussion, largely due to the widely publicized water shortagesin a number of heavily populated areas in the United States. Alarming, sometimes unabalanced, statements have been made referring, for example, to general lowering of the water table. These shortages and the ensuing discussion have brought about a much wider appreciation of the importance of water in our complex society.

Industry is a heavy user of the nation's water resources. With the recent occurrence of water scarcities throughout the country, and the concern over water quality, the use of water by industry has properly become one of the major elements in determining a national water policy.

Water is one of the essential raw materials for America's all-important industrial plant. A failure of water supply can halt operations in a steel plant just as surely as a failure of the coal supply.

This inescapable economic fact will be one of the important elements in shaping our national future. It will play a part in determining whether we can meet the challenge of agressors in the immediate future, and continue our historic improvement of living standards in the long-term future. A shortage of water for industrial purposes--just as surely as a shortage of manpower, of raw materials, or of capital--could defeat our hopes for future growth and prosperity, and even imperil our national safety.

No industry or business can long survive where water is unavailable or inadequate as to quantity and quality. When this fact, with all it implies, is fully appreciated, then one begins to realize the importance of water in the present and future development of industry and the nation. It then becomes apparent that access to and use of water is now a major resource problem, and bids fair to become even more so. Past utilization practices as they concern water are generally in as much need of change as of land and timber, if the future growth potential of the nation is to be realized.

If one must have proof of this fact, consider the implication of recurring water shortages that plague many cities and towns. How long will industry and business survive in, or be attracted to, areas of water shortages if fundamental changes are not made in the pattern of water use and development? The emergency remedial action in communities not facing water shortages is usually quite direct. Water is rationed, and in some cases portable filter units are brought in to pump water for human consumption through temporary pipelines laid from the areas of shortage to private lakes or to areas where the shortages are not so great and water therefrom can be spared!

This sort of action, however, does not permit expanded output in industry, business, or agriculture. It does little to alter the basic conditions that caused the shortage in the first place. Like most emergency measures, rationing of water and other actions connected with alleviation of shortages deal with the result, and not the cause, of the condition.

Thus, most authorities are in agreement that the ultimate solution to the problem of adequate water resources for public and industrial use is to be found only in long-range planning by water suppliers and users. It is also generally agreed that such planning must provide for the intelligent development, utilization, and conservation of local and regional water resources, in line with established and anticipated needs.

On the average, as indicated previously in information regarding the hydrologic cycle, about 30 inches of precipitation occurs annually over the United States. Records of the United States Geological Survey show that about 21.7 inches of rainfall annually returns to the atmosphere through evaporation and use by vegetation. Another 8.3 inches of precipitation runs off the surface of the land or through the ground directly into streams and thence into the ocean. Only about three-fourths of an inch of this run-off is intercepted annually and used directly by man.

Thus, there are tremendous possibilities for increasing the volume of water intercepted for use by the public and industry. Actually, it appears that we as a nation have hardly begun to develop the water resources that are available. The magnitude of this potential supply of water, obviously, cannot be realized in a matter of a few years or even decades. It does, however, indicate that the nation is by no means bound by what is known as the present water supply capacity. It also indicates clearly that many communities, whether they are industrial or agricultural or a combination of both, have enormous reserves of water that have not been developed.

The fact remains, however, that until such time as these tremendous reserves are developed, the public and industry in many areas face an immediate problem of obtaining a water supply adequate in quantity and quality. In these areas, there is the indisputable proposition that the demands upon present local water supply sources have grown faster than local water resource development. If industry, business, and indeed the whole of the economies in these areas are to continue growing, their problem is twofold.

1. These areas must take immediate steps to increase efficiency in the utilization of currently available water supplies through such measures as pollution abatement and increased reuse.

2. These areas must look beyond the original and easily accessible ground and surface water that have heretofore been adequate, and plan the financial and physical measures that are required to intercept more of the water that now escapes into the atmosphere and into the oceans.

Understandably, the general public in and out of water shortage areas has become aroused as to what can and should be done by industry, agriculture, water companies, and private home owners to eliminate serious or damaging pollution and wasteful water use practices.

The now pressing nature of current and prospective water supply problems nationally has led industrial leaders and others to delve more deeply into concepts of water use policies that now prevail in industry. Their concern is to discover the areas in the nation's water resource problem where water use practices by industry are not in harmony with future industrial development and to encourage a change in those practices accordingly. A few individual industries took an early initiative in appraising their own water use practices that were in need of revision. Subsequently, these few industries have developed

effective educational programs to encourage the adoption of more modern and scientific water utilization measures.

Some of the highlights of the survey by the National Association of Manufacturers and the Conservation Foundation of water use in industry are as follows:

1. The relatively few plants which use exceptionally large amounts of water account for the largest part of the aggregate industrial use.

2. The increase in the scale of industrial operations over the past decade has led to an increase in the intake of water by industry. However, other important factors have affected the amount of water required by industry, including a change in water-use practices.

3. Large industrial plants increased their water intake, in the period 1939 to 1949, by a greater percentage than small plants.

4. While, in general, the most common source of water for industrial plants is the municipal river or lake water plants, the industrial plants which require very large amounts of water more commonly derive them from their own river plants.

5. Among all industrial plants in this survey taken together, the most important requirement for water is for process purposes. Large amounts are also used for cooling, for sanitary and service purposes, and for boiler feed.

6. Among the large water users in particular, the greatest part of the water intake is used for cooling purposes.

7. Industrial plants differ greatly among each other in the extent to which they economize on water by reusing it. More than half of the plants surveyed do not reuse any of their water. A substantial number reuse their intake as much as two or three times.

8. About half of the industrial plants covered in this survey have their own facilities for treating water. Apparently the remainder either do not require water of a high degree of purity, or else obtain sufficiently pure water from municipal water systems.

9. A greater proportion of large plants than of small plants have their own water treating facilities. Evidently it is more economical for the large plants to treat their own water.

10. About four out of five industrial plants do not treat their waste water at all before discharge. A greater percentage of large plants than of small plants treat their waste water.

11. Small industrial plants usually dispose of their waste water through municipal sewers. However, the plants with very large amounts of waste water to dispose of most often use rivers for that purpose. (The fact that small plants dispose of their waste water through sewers helps to explain why so few of them have facilities for treating it.)

12. The users of exceptionally large amounts of water are fairly evenly distributed among the industrial metropolitan areas of the nation.

13. The East North Central Region--the most industrial area of the nation--has shown a greater percentage increase in industrial water use since 1939 than most of the other regions.

14. A great diversity of opinion exists among industrialists in most localities as to the potentialities for expanded use of water by industry in their areas.

15. Most industrialists believe that the status of pollution in their areas is either improving or remaining the same. Very few of them believe that it is growing worse.

Selection of Plant Sites - - The Blue Book of Southern Progress, published by the Manufactures Record, lists the value of all manufactured products in the 17 states at 11 billion dollars for the year 1939 and at 53 billion dollars for 1950, an increase of almost 400 per cent during the brief period of 12 years. Many of these industries moved south for various reasons. The attainment of a plentiful supply of soft, unpolluted water for both their present future needs was of prime importance.

In the early days, the use of water for manufacturing purposes was mainly incidental, and the use of water for domestic purposes was at a low rate of consumption. In those days, an industry was built along a stream for the primary purpose of building a dam and developing its own power. These river sites were comparatively limited in number and were subject to the ravages of floods. The coming of the large electric utility systems with their extensive network of transmission lines has forced industry from its dependence on water for motive power and has given it an almost unlimited choice of sites. One of the major considerations favoring location of industry in North Carolina at the present time is an adequate supply of water of suitable quantity and quality to satisfy their processing needs.

A report published by the National Planning Association, Committee of the South, sets forth the requirements for new plant locations in the order of their relative importance. Water is rated in third place; raw materials, and power and fuels, are first and second, respectively. It is possible that in North Carolina, as the major water-users, industry, municipalities, and irrigation, increase their demands, water supply will become the first consideration.

Industries must go where their vital water supply is assured for the present and the future. To these industries, the rivers and streams of the south, originating in the mountains and flowing to the ocean, offer an abundance of soft, easily treated water for all purposes. The water resources of North Carolina constitute a major industrial asset which will continue to bring to the State great and small industries which require large quantities of water.

Salt Water Intrusion - - Because of its geographic location, about one-fourth of the State of North Carolina is exposed to varying degrees of salt water intrusion of its surface and ground water sources. The degree of intrusion, and how far salt water extends above the mouths of the rivers, are questions that cannot be adequately answered at the present time. To date, only meager and inconclusive data are available. Questions concerning the chemical quality of water in the Coastal Plains area will be raised more often as the municipal and industrial growth of this area increases and the need for adequate

supplies becomes more acute. In order to remedy this situation, the study of chemical quality of water investigations in North Carolina is being expanded to determine the variations and extent of salt water intrusion in the tidal reaches of streams in the coastal areas. This determination is now in the preliminary survey stage, being carried on jointly by the State of North Carolina and the United States Geological Survey.

The study of salt water intrusion of tidal waters is important because of its bearing on the various phases of economic activity in the State. On tidal rivers that are navigable, there may be a concentration of population and industries. In order to fully utilize a stream, basic data on the chemical quality of the stream, its variations, and their causes are of special importance. High salinity may result in inefficient steam boiler operation, the modification of chemical processes using river water, or, in extreme cases, the possible shutdown of a plant or abandonment of the river as a source of water for municipal or industrial supply. The extent and frequency of variations in salinity are also of prime importance to agriculture depending upon irrigation, and to the shellfish industry. The effect on salinity of upstream diversions to storage reservoirs, canals, or irrigation is of basic interest in long-range planning of water usages. When the operation of such processes becomes economically feasible, knowledge of the salinity variation in the water supply may be the most important factor in locating the plant. In any study of infiltration of river water into the ground-water aquifers, basic data on the composition of the river water is a prerequisite.

In order to determine the variations and extent of salt water intrusion in tidal streams, the following factors should be determined:

(1) Uppermost limits of salt water intrusions in tidal streams;

(2) The range in concentration of salt water at any point in the tidal reach; and

(3) The volume of fresh water discharge that is required to maintain the concentration of salt water below a predetermined maximum at any point in the tidal reach.

The first step in determining these conditions is a study of the extent of salt water intrusion in the streams subject to tidal effects. In order to receive the maximum benefits for a comprehensive program to determine the chemical quality of the surface waters in the Coastal Plains area, a preliminary survey will be made of each river basin to determine the extent of salt water intrusion. This survey will be followed by a comprehensive program for each river basin.

A preliminary survey will be made of each of the major river basins in the Coastal Plains area to indicate the extent to which salt water has contaminated the fresh water streams. The survey will extend over a three-month period when the streams are at low flow and high flow. For those streams affected by tides, samples for chemical analyses will be collected during the tidal cycle at specific points on the stream to determine the maximum and minimum salt water intrusion. The following chemical determinations will be made on each sample collected: specific conductance, chloride, color, ph, iron, and hardness.

Samples will be collected at designated points along the streams as follows:

(1) During periods of high flow;
(2) During periods of low flow;
(3) During periods of high tide; and
(4) During periods of low tide.

After the preliminary survey for a river basin is completed, sampling stations for collection of daily samples for a continuous record will be established. In establishing a municipal or industrial water supply, it is important that continuous records be obtained in order that day-by-day changes in the chemical quality can be determined. This information is necessary for design of the treatment plant. In order to receive the maximum benefits from a comprehensive program, the following activities are necessary:

(1) Establishment of at least one daily sampling station on major streams for collection of samples for complete chemical analyses. This station would be above any possibility of salt water intrusion. Chemical determinations to be made would be as follows: specific conductance, color, iron, silica, calcium, magnesium, sodium and potassium, ph, bicarbonate, chloride, sulfate, nitrate, total hardness, and dissolved solids.

(2) Establishment of two or three (more if needed) stations in the tidal reach of the river for the collection of twice-daily samples at high tide and at low tide for partial chemical determinations to determine the variations in salt water concentration at each station. These determinations will be as follows: specific conductance, ph, iron, hardness, chloride, and sulphate.

(3) Preparation of at least four salinity profiles over a period of one year of the river from fresh water to salt water by means of a boat to determine the position of salt water front under changing conditions of river discharge. One profile would be made during low flow, one during high flow, and two during medium, or average, flow.

(4) Miscellaneous studies of local influences, such as run-off from small tributary streams in the tidal area, effect of shipping on pattern of salt water intrusion, and related problems.

(5) Preparation of report.

Due to possibility of abnormal rainfall or drought conditions, it is probable that a program as outlined above will extend over a minimum of two years.

Factors Determining Sources of Industrial Water Supply - - Water for industrial purposes is obtained from either surface or ground sources, or both. Factors determining sources of supply are accessibility, adequacy, continuity, suitability, quality, and temperature.

The quality and quantity of water used by industries vary so widely that each type of processing presents individual requirements which must be satisfied. Water for many uses is treated to obtain the quality required. Tremendous quantities are often used with no treatment, for example, cooling water.

Practically all industrial uses of water fall within four classifications, namely, cooling, processing, boiler feed, and sanitary and service water. Other uses of water account for only a small per cent of the total industrial requirement.

Roughly, the average industrial plant uses one quarter of its water for cooling, one quarter for sanitary and service purposes, one-eighth for boiler feed, and three-eighths for process purposes. These uses are the average uses, for the determination of which the large plants and the small plants count for equal weight.

If the four types of uses are listed in the order of greatest use for plants taking in less than 100,000 gallons daily, the order is sanitary and service, boiler feed, process, and cooling. If they are set down for plants using more than 100,000 gallons daily, the order is changed to process, cooling, boiler feed, and sanitary and service.

Among small users of water for industrial purposes, cooling is the least important use, and sanitary and service is the greatest use. In plants using extremely large quantities of water, the greatest part of the water is always accounted for by cooling.

It is of interest that only 11 per cent of the industrial plants in the United States use 92 per cent of the total industrial water intake. These plants each use in excess of 2,500,000 gallons of water daily. It is even more astonishing that less than 2 per cent of the plants use 35 per cent of the total water intake, and each uses in excess of 50,000,000 gallons daily.

Cooling Water - - Many industrial processes require temperature reduction, and water is generally the cheapest cooling medium. It is desirable that water be cool and non-corrosive. A high degree of purity, however, is seldom required. Water from both surface and ground sources is often used without treatment. Cooling water is sometimes circulated through cooling towers to reduce the quantity required and to lower the temperature required for further cooling use. Through use in this manner, it is required only to replace that water which is lost through evaporation.

The temperature of water to be used for cooling is of economic importance. It governs the design of equipment and the heat balance of many industrial processes. If surface water is used, consideration must be given to temperature fluxuations which follow the atmospheric temperature throughout the year. For this reason ground water is often more desirable because of its uniform temperature. Also during the summer months, a much higher efficiency is possible through the use of cooler ground water.

The use of cooling water for air conditioning has grown rapidly in recent years. Ground water is generally used for this purpose. Excessive pumping of ground water for air conditioning purposes in the business sections of some large cities in the United States has brought about laws and regulations which require the return of the water to the ground by the larger users.

Processing Water - - Water required for processing (water used in contact with the manufacture of a product) varies with the use and the type of product produced. Again, a great variation exists in the quality and quantity of water required. For example, water entering into or contacting food products must be low in mineral content and be bacteriologically safe. Any odor or taste in the water is detrimental. The quality of certain canned products is appreciably lowered by the use of hard water.

Quality of the process water is often a matter of more concern than quantity. To have water of special characteristics is generally important. Ground water is largely used for processing because of its more constant quality.

Boiler Feed Water - - Steam is used in some form in many types of manufacturing. The supply of water for boiler use must be pure enough to prevent corrosion and rapid formation of boiler scale. If the water supply available can not be rendered satisfactory for boiler feed except at prohibitive costs, then the locality is generally unfavorable for any large industrial development. A satisfactory supply of water for steam generation and condensing will probably be the major consideration in choosing the exact location for a steam plant in an area which is generally favorable in other respects.

A number of indsutries require large quantities of process steam. Low pressure steam is used in the process of paper digesting and textile finishing. Steam is used in the process of treating and heating materials as in evaporating and cooking in chemical, sugar, and food industries.

Sanitary and Service Water - - Use for sanitary purposes includes water for drinking, showers, and toilet facilities. Water which is bacteriologically safe and suitable for domestic use is required. Plants using water of lower quality in their operations usually rely upon a municipal supply as their source of water for sanitary purposes.

The size of water supply necessary for fire protection in plants varies with the size, type of buildings, and materials used in the processes. Some industrial operations are so hazardous from the standpoint of fire that large amounts of stored water are required.

Additional service water is required for such uses as cleaning and lawn sprinkling.

Industrial Requirements For Water - - Many of the larger amounts of water, required per unit produced in manufacturing and indicated in the following table, are based upon the water used for cooling in the process.

PRODUCT	UNIT PRODUCED	WATER REQUIRED (gallons per unit)
Airplane engine	To test	50,000-125,000
Alcohol	Gallon	100
Alfalfa	Acre	1,250,000
Aluminum	Pound	160
Aviation Gasoline	Gallon	7-10
Brewing		
Beer	Barrel	470
Whiskey	Gallon	80
Bromine	Ton	5,000,000
Buildings		
Office	Person	27-45 (per day)
Hospital	Bed	135-350 (per day)
Hotels	Guest Room	300-525 (per day)
Laundries		
Commercial	Pound "work"	4.3-5.7
Institutional	Pound "work"	3
Canning		
Asparagus	100 cases No. 2 cans	7,000

PRODUCT	UNIT PRODUCED	WATER REQUIRED (gallons per unit)
Beans		
Green	100 cases No. 2 cans	3,500
Lima	100 cases No. 2 cans	25,000
Pork and	100 cases No. 2 cans	3,500
Beets	100 cases No. 2 cans	2,500
Corn	100 cases No. 2 cans	2,500
Peaches	100 cases No. 2 cans	6,500
Pears	100 cases No. 2 cans	6,500
Peas	100 cases No. 2 cans	2,500
Pumpkin	100 cases No. 2 cans	2,500
Sauerkraut	100 cases No. 2 cans	300
Spinach	100 cases No. 2 cans	16,000
Tomatoes		
Products	100 cases No. 2 cans	7,000
Whole	100 cases No. 2 cans	750
Cement	Ton	750
Citrus fruit	Acre	1,500,000
Coke	100 tons	360,000
Cotton	Acre	800,000
Distilling, grain		
Combined wastes	1,000 bushels grain mashed	600,000
Thin slop	1,000 bushels grain mashed	600,000
Tailings	1,000 bushels grain mashed	600,000
Evaporator condensate	1,000 bushels grain mashed	600,000
Distilling, molasses	1,000 gallons 100 proof	8,400
Distilling, cooling water	1,000 gallons 100 proof	120,000
Electric Power	Kilowatt	80
Explosives	Pound	100 plus
Gasoline	Gallon	7-10
Grains	Acre	650,000
Ice Manufacture	Ton	244
Magnesium	Ton	300,000
Meat		
Packing House	100 hogs killed	550
Slaughterhouse	100 hogs killed	550
Stockyards	Acre	160
Poultry	100 pounds live weight	2,200
Milk		
Receiving Station	1,000 pounds raw milk	180
Bottling works	1,000 pounds raw milk	250
Cheese Factory	1,000 pounds raw milk	200
Creamery	1,000 pounds raw milk	110
Condensery	1,000 pounds raw milk	150
Dry milk factory	1,000 pounds raw milk	150
General dairy	1,000 pounds raw milk	340
Oil, edible	Gallon	22
Oil field	100 barrels crude oil	18,000
Oil refining	100 barrels	77,000
Paper		
Paper mill	Ton	39,000
Pasteboard	Ton	14,000
Strawboard	Ton	26,000

PRODUCT	UNIT PRODUCED	WATER REQUIRED (gallons per unit)
De-inking	Ton	83,000
Paper pulp		
Ground wood	One ton dry	5,000
Soda	One ton dry	85,000
Sulfate	One ton dry	64,000
Sulfite	One ton dry	60,000
Rail freight	Ton-mile	0.1
Smokeless powder	Ton	50,000
Soap factories	Ton	500
Soft drinks	Case	2.5
Steam power	Ton of coal	60,000-120,000
Steel, finished	Ton	65,000
Sugar	Pound	7
Tanning		
Vegetable	100 pounds raw hide	800
Chrome	100 pounds raw hide	800
Textile		
Cotton		
Sizing	1,000 pounds processed	60-820
De-sizing	1,000 pounds processed	1,100-1,750
Kiering	1,000 pounds processed	1,240-1,700
Bleaching	1,000 pounds rpocessed	300-1,200
Souring	1,000 pounds processed	3,400
Mercerizing	1,000 pounds processed	30,000
Dyeing		
Basic	1,000 pounds processed	18,000
Direct	1,000 pounds processed	6,400
Vat	1,000 pounds processed	19,000
Sulfur	1,000 pounds processed	5,400
Developed	1,000 pounds processed	14,400
Napthrol	1,000 pounds processed	4,800
Aniline black	1,000 pounds processed	15,600
Print works	1,000 pounds processed	4,500
Finishing	1,000 pounds processed	6
Knit goods	Pounds bleached	8
Rayon Manufacture	1,000 pounds produced	140-160
Rayon hosiery	1,000 pounds produced	9,000
Silk hosiery	1,000 pounds rpoduced	13,700
Woolens	1,000 pounds finished goods	70,000
Synthetic rubber	Ton	600,000

Responsibility for Public Recreation - - The universal recognition of the responsibility of various levels of government for public recreation is growing rapidly. There is increasing recognition that recreation means something more than amusement, and that it involves constructive use of leisure time which is becoming increasingly available for most people. The growth and development of public recreation in the last decade, together with the vast sums that have been spent for development of facilities and operation of programs, indicate the importance of recreation in the lives of people.

Recreation in its broadest sense is a continuation or expansion of education for adults as well as children. This is as true of the extensive, unorganized forms or recreation that involve use of large parks and forest reservations as it is of intensively supervised recreation in city playgrounds and community centers. Park and playground systems are increasingly being planned for and provided at municipal, county, and state levels. In 1945 North Carolina became the first state in the Nation officially to recognize the importance of recreation by creating a State Recreation Commission.

Recreational Use of Lakes - - The recreational use of lakes in North Carolina has grown to the proportions of big business. Many lakes have cottages on their shores, and thousands of people enjoy fishing, boating, and bathing on their waters each year. The demand for lake sites for permanent homes, as well as summer cottages, may make profitable the construction of dams to create lakes.

Lakes have been built in state and national park and forest areas. Fishing, boating, and bathing are permitted on these waters. The construction of cottages on the shores of these lakes, however, has been limited or prohibited in order to preserve their undisturbed sylvan settings.

For recreational use, it is desirable that a lake should have relatively pure, clear water, fairly constant levels during the recreation season, pleasing outline and setting, and good fishing possibilities.

In North Carolina, there are 198 natural and 170 artifucial lakes, along with our inlets, rivers, sounds, and 320 miles of shore line on the Atlantic Coast, which provide water recreation facilities for millions of people each year.

There are 28 State and Federal parks, forests, and historical sites, including the Great Smoky Mountain National Park and the Blue Ridge Parkway, which are the most visited national parks in the United States. There are more than 70 lakes with recreational facilities in these parks and forests.

Recreational Use of Streams and Other Water Areas - - The streams of North Carolina in past years lost much of their value for recreation with the increase in urban population and industrial activity which resulted in stream pollution. This result reduced the number of desirable species of fish in some places. Pollution also caused the streams to become unpleasant to sight and smell below sewer and industrial waste outfalls. The present program of pollution abatement, which the State Stream Sanitation Committee is effecting, is beginning to bring streams back to greater importance in the recreational field. Clean, clear water improves the quality and quantity of fishing and makes boating a pleasure.

Recreation is now of such importance that it is provided for, whenever practicable, in the planning of flood control, water supply, and hydroelectric reservoirs.

Water areas, including streams, rivers, natural and man-made pools, and ocean beaches, have a special recreational appeal. North Carolina is blessed with a bountiful supply of these recreational facilities. All water projects should be appraised, realistically and economically, with regard to the probable influence on recreational use, fish, and wild life.

Classes of Recreational Facilities - - Water recreational facilities can be classified in four groups, swimming, boating, fishing, and hunting. Our beaches on the Atlantic Coast are the greatest attractions for swimming. Boating is very popular wherever there are large enough lakes or ponds. However, the ocean sounds, rivers, and inland waterways are our greatest playgrounds for this sport. The Inland Waterway from Virginia to South Carolina extends for 298.8 miles. There are two routes from Norfolk to Albemarle Sound, one via the Dismal Swamp, and the other via Great Bridge and Coinjock. North Carolina waters offer endless variety to sports-fishermen. In the mountains, there are hundreds of miles of clear mountain streams and 75 lakes, where a dozen species of fighting fish may be found. In the Piedmont Plateau area, the rivers, lakes, and ponds provide the local angler with several species of fighting fish.

Coastal Area Recreational Facilities - - The coastal area of North Carolina is divided into six divisions as follows: (1) Southeastern Coast, (2) Cartaret Coast, (3) Central Coast, (4) The Outer Banks, (5) Northeastern Coast, and (6) Currituck Coast.

Coastal fishing grounds offer a wide variety of catches from the ocean. North Carolina claims two of the most famous migatory-wildfowl hunting grounds in the world. One is Lake Mattamuskeet in Hyde County, and the other is the Currituck Sound Country, known far and wide for both geese and ducks. Fish and wildlife constitute a resource of major importance, both commercially and from the standpoint of recreation.

Recreational Value of Water Projects - - Water projects can adversely affect recreation, fish, and wildlife, and projects should be appraised as to this possibility. Where commercial hunting, trapping, and fishing are involved, an approximate monetary estimate is possible. In general, damages are no more susceptible to appraisal than the benefits previously discussed. Inability to evaluate damages, however, does not imply that they are unimportant and to be disregarded. Priority of water use, availability of equivalent facilities, economical consequences, commitments, and other considerations of present and long-range welfare should control the decision. No arbitrary chosen set of monetary values can replace the need for sound judgment.

It is realized that, in some cases, the recreational values of reservoirs have been recognized and given weight by Federal agencies in justifying the expenditure of government funds for flood control, power development, and soil conservation. The importance of the contribution, which these resources are making to the economy and the broadened living opportunity of the citizens of North Carolina, should be borne in mind.

Wildlife Resources Commission - - The State, realizing the recreational and commercial importance of fish and wildlife resources, protects and improves these resources through the Wildlife Resources Commission. The Commission is developed around a nucleus of five fundamental, essential conservation

activities: regulation, enforcement, education, management, and research. The Commission employs effectively and economically some 225 paid personnel in rendering maximum service to tens of thousands of North Carolina sportsmen. An example of the magnitude and efficiency of the Commission's work is shown by revenue figures for Fiscal Year 1951-1952, totaling receipts of $1,422,551 and expenditures in the amount of $1,368,826.

Parks and Tourists - - Recreation in North Carolina includes many of the nation's greatest resources in which are included the mountains, beaches, natural and man-made lakes, national and state parks, and rivers. To facilitate the use and enjoyment of these resources, the Division of State Parks operate a diversified system of parks. State Parks property is valued in excess of six million dollars and consists of ten state parks and seven state historical parks, located from the mountains to the Atlantic Ocean. The State Parks personnel consist of 31 full-time and 50 summer-seasonal and additional part-time employees. Attendance at the parks from January 1 through September 30, 1954 was in excess of two million people. Those enjoying water recreation facilities were second in number of attendance. The tourist industry receipts amount to more than 400 million dollars annually in North Carolina, with the greatest trend toward aquatic recreational facilities. It is evident that the State Parks facilities for the enjoyment of recreation play an important part in this volume of business.

Potentiality of Development - - The rivers of North Carolina are relatively small and short in length. There are no large watersheds in the Mountain Region that would lend to the development of good water power. The only exception is the Roanoke River. Studies by the Corps of Engineers, Department of the Army, and by the staff of the North Carolina Utilities Commission indicate that the power possibilities of our rivers have not been completed, but that the remaining undeveloped potential hydroelectric sites in the State which are not now under consideration for future development are not large in relation to the total capacity of hydroelectric and steam plants now in operation.

Power-plant Operations - - Privately-owned power companies now operate 37 hydroelectric plants in North Carolina, having a total generation capacity of 480,000 kilowatts. These companies also own and operate 12 steam plants in the State, which have a total capacity of 1,611,000 kilowatts and enable the companies under changing water conditions to get maximum benefits from the hydroelectric plants.

These privately-owned companies have increased their hydroelectric generation in North Carolina from 460,000 kilowatts at the beginning of 1946 to only 480,000 kilowatts at the end of 1953. During the same period, however, they have increased their steam generation from 655,000 kilowatts to 1,611,000 kilowatts. During this same period, local, state, and federal taxes paid by these privately owned companies have increased from approximately $16 million for the year 1946 to $36 million for the year 1953. The kilowatt-hour cost to consumers has steadily decreased in North Carolina from year to year with the increase in consumption, and the rates in the State compare favorably with the national average.

An abundance of cheap power has been available at all times to meet the ever-increasing need for electric power, and experience with these companies under State supervision and regulation well justifies the faith of the people of the State in the ability of private enterprise to supply its needs in this field.

Usefulness of Rivers for Power - - As a source of vital water supply for both industrial and domestic purposes, the rivers of North Carolina have entered a new phase of usefulness for the material advancement of the State. During the first quarters of this century, the hydroelectric development of the rivers helped to awaken the State to its industrial possibilities and brought to the State many large industries, which are large consumers of electric energy. The harnessing of rivers for electric energy production, and the importance of dependable supplies of low cost electrical power, have been one of the prime factors in the growth of our industries. Some of the facts bearing on the relation between water and power follow.

(1) During 1951, only 23% of the electric energy supply for public use in the South was produced in hydroelectric plants, and the remaining 77% came from fuel-burning generating plants. The percentage of power produced in the future by hydroelectric plants will continue to decrease.

(2) Most of the economical hydroelectric plant sites in the South have already been developed. The undeveloped sites, even if they could be developed economically, would contribute but a small portion of the huge additional electric energy demands of the fast-growing South. For the future, dependence must be placed on large, modern and efficient fuel-burning electric-generating plants, which are capable of mass production of large blocks of dependable electric energy.

(3) Electric energy production requires large quantities of water. For instance, a flow of one million gallons a day, when utilized in a hydroelectric plant, with a head of 100 feet, would deliver to the consumer only 250 kilowatts per hour, which, if sold at average industrial rates, would bring in about two dollars. Modern steam-electric generating plants also require large quantities of water for condensing purposes. These requirements are only about one per cent of the requirements of a hydroelectric plant, with a head of 100 feet, for the same electric energy output. Even this water requirement of the steam plant can be reduced by as much as 95 per cent by the use of cooling towers. The rivers of the South should, therefore, be sufficient for the electric generation requirements for a long time in the future.

Transmission System - - North Carolina has a complex system of transmission lines, which serves not only to deliver power to all parts of the State, but also to inter-connect the major utilities operating within the State with each other as well as with the utility systems of other states. The State Utility Commission has a map, showing the important transmission lines and substations, and the points of interconnection between utilities within the State and with utilities of neighboring states.

A majority of the municipal generating plants either now have an interconnection with this transmission system or have an arrangement for inter-connection in process of construction. Such an arrangement makes for much greater reliability of service in the system and effects a greater economy of operation.

The inter-connection of the major utility systems in the State with systems in neighboring states also makes possible greater reliability of operation. Inter-change of power is made in most cases in both directions. Contracts are made from year to year and vary with local conditions. During the period of emergency, when the Carolina Aluminum Company was forced to operate at its maximum capacity in the defense effort, large amounts of energy were imported from outside the State and delivered to Badin through the local transmission system.

Transmission voltages vary from 22 kv. to 161 kv. The trend in most companies is to consider 22kv. as a distribution voltage.

Major Producers of Power - - The Duke Power Company and the Carolina Power and Light Company are the major producers of power in North Carolina. Each of these companies has a sizeable amount of hydroelectric generation in combination with a large amount of steam-generation. Such a combination is ideal because hydroelectric power can be used much more effectively in conjunction with steam generation than when operated alone. The firm capability of isolated hydroelectric power may run as low as 25 to 35 per cent of rated capacity, while its full rated capacity may be available for peaking purposes under favorable water conditions.

The following data show the capacity of the available systems (North and South Carolina) of the Duke Power Company and the Carolina Power and Light Company, together with their available sources and the peak loads of their systems in 1951.

DUKE POWER COMPANY

Hydro Generation	497,103 Kw
Steam Generation	1,077,500 Kw
Other sources	
Carolina Aluminum (peaking)	30,000 Kw
S. C. Electric and Gas Company	26,000 Kw

Miscellaneous	2,397 Kw
Total	1,633,000 Kw
Peak Load 1951	1,534,000 Kw
Margin	99,000 Kw

CAROLINA POWER AND LIGHT COMPANY

Hydro Generation	187,000 Kw
Steam Generation	293,000 Kw
Other Sources:	
Appalachian Electric Power Company	40,000 Kw
S. C. Electric & Gas Company	55,000 Kw
Duke Power Company	14,000 Kw
Santee-Cooper	27,000 Kw
Carolina Aluminum (peaking)	16,000 Kw
City of Rocky Mount	15,000 Kw
City of Wilson	7,000 Kw
Tidewater Power Co. (peaking)	10,000 Kw
Total	664,000 Kw
Peak Load 1951	638,000 Kw
Margin	26,000 Kw

If load growth follows the pattern of the past few years of 12% per year, the margin of reserve power for these two companies will be in accordance with the following tables.

DUKE POWER COMPANY

	ESTIMATED PEAK LOAD	TOTAL SUPPLY	MARGIN
1951	1,534,000 Kw	1,633,000 Kw	99,000 Kw
1952	1,718,000	1,833,000	115,000
1953	1,924,200	2,083,000	158,800
1954	2,155,100	2,333,000	177,900
1955	2,413,700	2,483,000	69,300

CAROLINA POWER AND LIGHT COMPANY

1951	638,000 Kw	664,000 Kw	26,000 Kw
1952	675,300	789,000	113,700
1953	756,400	789,000	32,600
1954	847,100	889,000	41,900
1955	948,800	989,000	40,200

DISPOSITION OF ENERGY IN NORTH CAROLINA BY MAJOR UTILITIES

DUKE POWER COMPANY

Sales of Energy by Accounts	Number of Customers	Kwh Sales in 1951
Res. or Domestic	435,966	958,567,315
* Rural (included above)		
Commercial & Industrial	50,778	2,966,687,871
Street & Highway Lighting	138	17,211,532
Sales to Railroads	1	4,495,404
Interdepartmental Sales	52	7,910,562
Sales to Other Utilities	43	432,334,584
	486,978	4,387,207,268

*Since Duke Power rates are the same for urban and rural customers, no separation is made in company records. (This footnote concerns the asterisk on the preceding page.)

DISPOSITION OF ENERGY IN NORTH CAROLINA BY MAJOR UTILITIES

CAROLINA POWER AND LIGHT COMPANY

Sale of Energy by Accounts	Number of Customers	Kwh Sales in 1951
Res. or Domestic (urban)	108,285	329,005,000
Rural	76,010	165,623,400
Commercial & Industrial	19,028	1,162,023,600
Street and Highway Lighting	109	10,889,200
Sales to Public Authorities	992	24,255,000
Sales to Other Utilities	59	534,226,100
Total	204,483	2,226,021,200

VIRGINIA ELECTRIC AND POWER COMPANY

Residential or Domestic	27,404	60,330,719
Rural (included above)		
Commercial and Industrial	4,746	148,738,565
Street and Highway Lighting	61	1,055,718
Sales to Public Authorities	436	3,570,535
Sales to Other Utilities	15	69,124,006
Total	32,662	282,819,543

NANTAHALA POWER AND LIGHT COMPANY

Residential or Domestic	1,472	6,733,060
Rural	6,901	9,350,855
Commercial and Industrial	1,188	39,696,971
Other Sales (ALCOA)	1	274,107,200
Sales to Other Utilities	4	7,311,750
Total	9,571	337,530,869

TIDEWATER POWER COMPANY

Residential or Domestic	40,572	76,176,900
Rural (included above)		
Commercial and Industrial	9,413	104,198,158
Street and Highway Lighting	53	1,684,272
Sales to Public Authorities	629	8,263,655
Sales to Other Utilities	15	45,407,466
Total	50,682	235,730,451

DISPOSITION OF ENERGY BY MINOR UTILITIES HAVING GENERATION

CAROLINA MOUNTAIN POWER COMPANY

Residential, Rural and Commercial, (no segregation reported)	550	970,000
Sales to Other Utilities	1	7,042,200
Total	551	8,012,200

DISPOSITION OF ENERGY BY MINOR UTILITIES HAVING GENERATION

DILLSBORO AND SYLVA ELECTRIC COMPANY

Sales of Energy by Accounts	Number of Customers	Kwh Sales in 1951
Residential	613	940,386
Rural	872	946,371
Commercial	262	2,172,660
Street and Highway Lighting	2	359,040
Total	1,749	4,418,457

PAMLICO POWER AND LIGHT COMPANY

Residential	842	965,634
Rural (included above)		
Commercial	242	411,105
Total	1,084	1,376,739

NEW RIVER LIGHT AND POWER COMPANY

Residential	775	1,677,964
Rural	258	389,504
Commercial and Industrial	246	1,745,866
Street and Highway	2	53,732
Total	1,281	3,885,909

DISPOSITION OF ENERGY BY MINOR UTILITIES HAVING NO GENERATION

CRISP POWER COMPANY
Macclesfield, North Carolina

Sales of Energy by Accounts	Number of Customers	Kwh Sales in 1951
Rural	160	203,065

NOTE: Energy purchased from Edgecombe-Martin Electric Membership Corporation.

DAVENPORT POWER AND LIGHT COMPANY
Tarboro, North Carolina

Rural	617	614,756

NOTE: Energy purchased from Town of Pinetops and Town of Macclesfield

DOMESTIC ELECTRIC SERVICE
Rocky Mount, North Carolina

Rural	739	989,744
Commercial	82	357,420
Total	821	1,347,164

NOTE: Energy purchased from City of Rocky Mount

C. L. HARDY AND COMPANY
Maury, North Carolina

Rural	758	905,386
Commercial and Industrial	28	146,875
Total	786	1,052,261

NOTE: Energy purchased from City of Greenville.

LAUREL HILL ELECTRIC COMPANY
Laurel Hill, North Carolina

Sales of Energy by Accounts	Number of Customers	Kwh Sales in 1951
Residential and Commerical	347	707,369

NOTE: Energy purchased from Carolina Power and Light Company.

PISGAH MOUNTAIN ELECTRIC COMPANY
Lincolnton, North Carolina

Rural	409	587,419
Commercial	22	118,478
Total	431	705,897

NOTE: Energy purchased from Duke Power Company.

ROANOKE UTILITIES COMPANY
Manteo, North Carolina

Residential and Rural	614	902,192
Commercial	99	405,826
Total	713	1,308,018

NOTE: Energy purchased from Virginia Electric and Power Company.

PINEHURST, INC.
Pinehurst, North Carolina

Residential	391	1,046,366
Commercial	101	1,610,030
Total	492	2,656,396

NOTE: Energy purchased from Carolina Power and Light Company.

Comparison of Rates - - Cost of electricity for residential service in North Carolina is below the National average. From the report of the Federal Power Commission for 1952 the average cost for 100 Kwh over the entire United States was $3.76, and for 250 Kwh the average cost was $6.97. In North Carolina the average cost for 100 Kwh was $3.60 and for 250 Kwh was $6.79. The following tabulation taken from the same Federal Power Commission report gives a comparison of the average costs in neighboring states to those in North Carolina for 1952.

State	Cost of 100 Kwh	Cost of 250 Kwh
Florida	$4.61	$7.61
Georgia	3.56	5.91
South Carolina	3.51	6.53
North Carolina	3.60	6.79
Virginia	3.69	7.32
Maryland	3.73	7.60
West Virginia	3.92	7.23
Tennessee	2.50	5.04
Alabama	2.97	5.76

During the past twenty years the use of electricity by residential customers has increased fourfold, while the average cost of electricity to these residential customers has steadily decreased. These facts are illustrated by the following tabulation.

AVERAGE MONTHLY KILOWATT HOUR CONSUMPTION AND COST FOR RESIDENTIAL CUSTOMERS OF FOUR MAJOR POWER COMPANIES IN NORTH CAROLINA, 1931 to 1951, inclusive .

	C P & L		DUKE POWER CO.		TIDEWATER		VA. ELECTRIC	
Year	Av. Mo. Cons.	Cost Per Kwh	Av. Mo. Cons.	Cost Per Kwh	Av. Mo. Cons.	Cost Per Kwh	Av. Mo. Cons.	Cost Per Kwh
1931	54	6.52¢	50	6.30¢	34	8.14¢	55	5.44¢
1932	55	6.29	51	5.60	38	7.85	58	5.04
1933	55	5.91	51	5.25	40	7.43	59	4.75
1934	57	5.81	54	5.05	44	7.33	65	4.51
1935	70	4.65	57	4.51	47	6.95	78	4.07
1936	84	3.82	64	4.21	51	6.34	86	3.79
1937	95	3.36	70	4.00	55	6.00	97	3.77
1938	100	3.25	74	3.65	57	5.57	98	3.61
1939	105	3.15	78	3.55	61	5.19	98	3.67
1940	110	3.07	82	3.30	62	4.97	100	3.43
1941	114	2.98	91	3.10	68	4.89	102	3.39
1942	115	2.96	87	3.05	73	4.54	101	3.39
1943	121	2.90	91	3.02	85	4.14	107	3.30
1944	126	2.86	102	2.96	94	3.98	112	3.25
1945	130	2.84	105	2.91	102	3.86	117	3.11
1946	141	2.77	115	2.81	106	3.62	126	2.90
1947	150	2.73	129	2.65	118	3.43	132	2.89
1948	167	2.60	147	2.46	122	3.33	148	2.72
1949	184	2.51	160	2.34	135	3.26	161	2.67
1950	196	2.42	177	2.25	147	3.25	170	2.62
1951	224	2.34	183	2.18	156	3.21	183	2.54

Costs for Commercial Lighting Service are given by cities in the following excerpt from the 1952 Federal Power Commission report, for cities in the southeastern states of comparable population to cities in North Carolina.

COST OF ENERGY

CITY	POPULATION	3 Kw 375 Kwh	6 Kw 750 Kwh	12 Kw 1500 Kwh	Company Serving
S. Petersburg, Fla.	96,738	19.41	35.03	57.00	Fla. P. & L. Co.
Orlando, Fla.	52,738	21.38	38.00	61.75	Orlando Util. Comm.
Tampa, Fla.	124,681	16.25	27.50	50.00	Tampa Elec. Co.
Columbus, Ga.	79,611	13.33	25.44	49.66	Georgia Power Co.
Savannah, Ga.	119,638	18.63	35.50	61.75	Sav. El. & Pr. Co.
Columbia, S. C.	86,914	14.72	26.68	45.66	S. C. El. & G. Co.
Charleston, S. C.	70,174	14.26	27.38	46.14	S. C. El. & G. Co.
Greenville, S. C.	58,161	12.70	22.20	40.95	Duke Power Company
Charlotte, N. C.	134,042	12.70	22.20	40.95	Duke Power Company
Greensboro, N. C.	74,389	12.70	22.20	40.95	Duke Power Company
Raleigh, N. C.	65,679	12.30	21.15	39.97	Carolina P. & L. Co.
Alexandria, Va.	61,787	14.85	26.97	48.72	Va. Elec. & P. Co.
Portsmouth, Va.	80,039	15.38	28.50	54.75	Va. Elec. & P. Co.
Roanoke, Va.	91,921	11.70	23.10	45.90	App. Elec. P. Co.
Baltimore, Md.	949,708	12.32	23.57	46.42	Consol. G. & El. Co.
Cumberland, Md.	37,679	14.88	23.75	41.75	Potomac Edison Co.
Charleston, W. Va.	73,501	11.70	23.10	45.90	App. Elec. P. Co.
Wheeling, W. Va.	58,891	13.30	23.10	45.90	Wheeling El. Co.

CITY	POPULATION	3 Kw 375 Kwh	6 Kw 750 Kwh	12 Kw 1500 Kwh	Company Serving
Chattanooga, Tenn.	131,041	10.00	17.50	27.50	Chat. Power Board.
Memphis, Tenn.	396,000	11.50	20.13	31.63	Memphis L. &.G. Div.
Birmingham, Ala	326,037	11.18	22.05	49.80	Birm. Elec. Co.
Mobile, Ala.	129,009	9.80	19.30	39.90	Ala. Power Co.

Costs for Industrial Power service are tabulated below for the same cities. Data taken from the 1952 Federal Power Commission report is given for three values of monthly Kw demand and corresponding Kwh monthly consumption for 200 hours use of demand.

CITY	75 Kw 15,000 Kwh	300 Kw 60,000 Kwh	1,000 Kw 200,000 Kwh
St. Petersburg, Fla.	$380.	$1203.	$3415.
Orlando, Fla.	269.	944.	3044.
Tampa, Fla.	289.	930.	2731.
Columbus, Ga.	290.	968.	2752.
Savannah, Ga.	294.	1036.	2925.
Columbia, S. C.	220.	874.	2570.
Charleston, S. C.	300.	952.	2631.
Greenville, S. C.	205.	779.	2506.
Charlotte, N. C.	205.	779.	2506.
Greensboro, N. C.	205.	779.	2506.
Raleigh, N. C.	218.	868.	2888.
Alexandria, Va.	327	1043.	3117.
Portsmouth, Va.	247.	863.	2564.
Roanoke, Va.	318.	1069.	3271.
Baltimore, Md.	341.	1260.	4039.
Cumberland, Md.	337.	1197.	3624.
Charleston, W. Va.	318.	1069.	3271.
Wheeling, W. Va.	306.	1024.	3121.
Chatanooga, Tenn.	205.	650.	1810.
Memphis, Tenn.	224.	748.	2082.
Birmingham, Ala.	206.	820.	2550.
Mobile, Ala.	263.	978.	2961.

From the foregoing data it is apparent that rates for residential, commercial, and industrial electric service in North Carolina are lower than most of those in the neighboring states, with the exception of states in T. V. A. territory.

Classifications of Surface Water - - The water that collects on the surface of the land may be divided into two general classifications as to occurrence, water in streams and water in lakes and ponds. The principal difference in these two classifications is that the former is in a state of more or less rapid movement which constantly brings new supplies to any given point on a stream. The water in lakes and ponds is more static in mature, is transported more slowly than in streams, and has its volume affected more directly by precipitation and evaporation.

Stream Flow - - Not all of the effects of rainfall are reflected by streams during or immediately after the rainfall occurs. Some of these effects show up months later. During the spring months a considerable part of the precipitation soaks into the ground to fill up underdround reservoirs where vast quantities may be stored. As these reservoirs become overfilled, the excess water drains out through springs and seeps and finds its way into streams. Water moves slowly in the earth, and the draining process may continue for months. However, the greater the excess in the ground, the greater the rate at which it will flow out of the ground. The ground water discharge is one of the most important factors in maintaining the low water flow of streams. During the late summer and fall months, when direct surface run-off from rainfall is small, it is the ground water discharge that keeps the streams flowing. Therefore, soil conservation, reforestation, and detention reservoirs, concerning which information may be found in subsequent chapters, are of great importance for storage, during periods of abundance of water, for the purpose of having available supplies of water for use during periods of drought. The influence of ground water discharge is so great that it is possible to have streams flow above normal when precipitation is below normal.

The cumulative effects of the multitude of factors that cause stream flow to vary are so complex that they have defied hydrologists to analyze them completely. It has, therefore, been impossible to make a satisfactory determination of day to day or month to month stream discharge from an analysis of precipitation and other hydrologic data. The only dependable and accurate method for determining the rate and volume of water carried in our streams is to make continuous, or at least daily, observations of the stream flow at selected places.

The important information about a stream is the quantity and quality of the water integrated with the respective stages of the stream in periods of drought, as well as in periods of floods. The information is important in planning municipal and industrial supplies; in designing, constructing and operating hydraulic works of all kinds; in drainage, sewage disposal, and pollution abatement programs; in designing highways, bridges, and culverts; in outlining recreational development; in irrigation; and in navigation. To supply reliable information for these needs, records of stream flow must be collected over periods of many years. In general, the longer the period for which a continuous record is available, the more valuable the record becomes.

Importance of Stream Gaging - - Records of river and stream discharge are among the principal tools used by engineers in evaluating any type of developments concerned with the use or control of water and in planning the layout and design of structures and machinery that compose such developments. They afford a sound basis for the economic study of any such project and a basis for design that will assure stability and safety of structures that might otherwise

endanger life and property. Without these records of maximum and minimum flows over an extended number of years, the engineer or development company is hopelessly handicapped, and the ultimate decision or design must rest upon guess work. There are few reliable persons or corporations who are willing to hazard their reputation or capital on a mere guess, regardless of how scientific that guess might be. The lack of reliable data involves a risk much greater than the developer should be called upon to assume, and the inevitable result is to retard development and progress until this information can be procured. Results disastrous to the individual, the community, and economic welfare are likely to occur if water-supply regulating or control projects are undertaken without due consideration of these fundamental data.

Stream flow records are essential in the investigation, design or operation of public water supplies, pollution of streams, water power projects, navigation improvements, waterway openings for bridges and culverts, flood control projects, steam power generating stations, and drainage projects, and they are often used by courts in the settlement of disputes arising from the use, regulation, or control of water.

In accordance with cooperative agreements between the Director of Conservation and Development, State of North Carolina, and the Director, Geological Survey, U. S. Department of the Interior, whereby the Federal Government matches funds made available by the State, the District Engineer, U. S. Geological Survey, Raleigh, North Carolina, measures stream flow at about 140 gaging stations throughout the State and the data obtained from these measurements are published in pamphlet form.

Stream Gaging Precedure - - The basic data collected at gaging stations consists of records of stage, manual measurement of discharge, and general information used to supplement the records of stage and discharge in determining the daily flow. The records of stage are obtained either from direct readings on a non-recording gage by an observer or from a water-stage recorder that gives a continuous record of the fluctuations. Measurements of discharge are made with a current meter which gives the average velocity in the section. The velocity, when multiplied by the cross-sectional area, gives the discharge of the stream. Rating tables that give the discharge for any stage are prepared from the discharge measurements. The application of the daily mean gage height to these rating tables gives the daily mean discharge, from which the weekly, monthly, and yearly mean discharges are computed. If the stage-discharge relation is subject to change because of frequent or continuous change in the physical features that form the control, the daily mean discharge is determined by the "shifting control method", in which correction factors based on the individual discharge measurement are used in applying the gage heights to the rating tables.

At some gaging stations, the stage-discharge is affected occasionally by backwater and, at some stations, by rapidly changing stage. The ordinary rating table does not apply under these conditions, and some supplementary information is used in determining the discharge.

Some of North Carolina's streams show some ice effect during extremely severe winters. The usual stage-discharge relation does not apply for these periods of ice effect, and discharge for these periods is computed on the basis of a gage-height record and occasional winter discharge measurements, consideration being given to the available information on temperature, precipitation, hydroelectric-plant records, notes by gage observers and engineers, and comparable records of discharge in the same or nearby basins.

Most of the gaging stations in North Carolina are now equipped with automatic recording gages. For those not equipped with recorders, a record of stage has been obtained by one or two readings a day, occasionally supplemented by additional readings during periods of high water. The types of non-recording gages used in this State are chain or wire-weight gages and vertical gages. The chain or wire-weight gage is simply a weight on a cable or chain, which is lowered from a bridge to the water surface, and the gage height is read from a scale. A vertical gage, as the name indicates, is merely a vertical staff gage graduated to two hundredths of a foot. It may be attached to a bridge pier, abutment, tree, or gage house, and may be in one or several sections extending from low water to the maximum flood level. For periods of rapidly changing stage, the daily mean discharge and the peak discharge at non-recording gages are often determined from gage-height graphs based on gage readings. The recording gage is housed in a shelter over a stilling well, generally of concrete, placed in a river bank and connected with the river by intake pipes which allow the water level in the well to follow the river level and which are placed at an elevation below the minimum stage of the river or stream. These gage houses are extended above the anticipated maximum flood elevation. The recording instruments are of several types. They contain as one element a mechanism for recording the rise and fall of the water level by means of wire attachments to floats in the stilling well, and, as another element, a clock mechanism that permits the recorder chart to move at a given constant speed. This chart gives a complete, continuous record of the fluctuations of the river or stream.

The zero of a gage or the gage datum is placed at an arbitary datum and has no significant relation to zero flow or the bottom of the river. At most stations, the zero of the gage is merely located somewhat below the lowest known stage so that negative gage readings will be avoided.

Accuracy of Data and Results - - The accuracy of the stream flow data depends largely on (1) the permanency of the stage-discharge relation and (2) the accuracy and frequency of observation of stage, measurement of flow, and interpretation of available data. The purposes for which the records are collected and the amount of funds available for the work determine to a large extent the accuracy of the records. Additional field data, obtained as a result of large floods or severe droughts, often make it possible to obtain a better definition of the rating curve and hence permit revision of older records that were computed from inadequate information. The accuracy of the records for the different stations varies quite considerably. For many of the stations, the daily figures are considered to be accurate within five per cent except for periods affected by back water, ice, or other changes in the control that have not been adequately defined. For some stations, the probable accuracy is not better than ten per cent, with some portions of the record even less accurate at times. These limits of accuracy and the fact that there is a variation in accuracy for some stations from one year to another should be kept in mind by the user of this data. Extreme accuracy is not possible without prohibitive cost. Any plans for utilization of the waters in a stream should provide a reasonable factor of safety. The run-off data provided are generally of a greater degree of accuracy than other factors, such as the average precipitation for a drainage area, which is ordinarily based on the assumption that records collected at only a few points are applicable over the entire area.

Basic Studies and Technological Research - - The State of North Carolina should increase its study of the basic components of water supply, including rainfall, run-off, percolation, infiltration, stream flow, ground water supplies, flood levels, and quality. These studies are of great value to industry as well as to public projects. They should be on a scale commensurate with

the growth requirements for the data. Without sufficient information, there will be no adequate basis for judgments on the highest uses of water resources or on the relationship of estimated cost to benefits. The basic data should be made available to business concerns on a wide scale, and could be particularly useful in helping industries to determine where new plants should be located, or in developing new sources of water.

In planning for the future development of the water resources of the State, it is of the utmost importance that the topographic mapping of the unmapped portion of the State be completed as soon as possible. Accurate topographic maps are regarded as a prerequisite for developments and programs involving land and water utilization. They are important in planning flood control and reclamation projects, and in classification and conservation programs. They provide basic data at a minimum cost for making preliminary studies of available reservoir sites and the extent of drainage areas. They also serve as the base maps for geological and military purposes.

Lakes and Ponds - - A lake is defined as a considerable inland body of standing water. A pond is a small inland body of standing water . A lake is considered to be a body of water covering five acres of land or more, and a pond to be a body of water covering less than five acres of land. Small ponds will not be included in this report. It is estimated that there are approximately two thousand farm ponds in North Carolina, and the number of these ponds is steadily increasing because of the drought during the past two years.

There are two classes of lakes, natural lakes and artificial lakes. Artificial lakes are those created by dams, so constructed as to impound water for flood control, navigation, hydroelectric power, and municipal water supply. A large number of the natural lakes are found in the central part of the State. The man-made lakes are found in the foot hills of the Mountain Region. The largest natural lake, covering an area of 42,000 acres, is found in the coastal area and is called Mattamuskeet Lake. The largest man-made lake is High Rock Lake, covering an area of 15,180 acres and located east of Salisbury.

According to a survey of information available from soil maps and road maps, it is estimated that there are 360 lakes in the State, of which approximately 200 are natural lakes and 160 man-made lakes. The total land area of the State is 33,735,680 acres, including the Outer Banks along the Atlantic Ocean. In the coastal area, an area of 2,055,355 acres is covered by sounds and inlets. The inland lakes cover an area of 229,465 acres, which is approximately seven-tenths of one per cent of the total land area. The natural lakes cover an area of 103,740 acres, and the man-made lakes cover 125,725 acres.

Information regarding extent of various water areas in North Carolina is shown in the following table.

STATE OF NORTH CAROLINA
TOTAL SQUARE MILES 52,712
TOTAL ACRES 33,735,680
TOTAL SQUARE MILES COVERED BY WATER
3,570 sq. mi. = 2,284,848 Ac.
TOTAL SQUARE MILES NOT COVERED BY WATER
49,097 sq. mi. = 31,422,080 Ac.

RIVER BASIN	TOTAL SQ. MILES	TOTAL ACRES	COVERED BY WATER ACRES	NO. OF LAKES	COVERED BY WATER NATURAL	NO. OF LAKES	COVERED BY WATER ARTIFICIAL
Hiwassee	650	416,000	14,553 Ac	0	0	4	14,553
Little Tenn.	1,875	1,200,000	18,136	3	58	14	18,078
French Broad	2,825	1,808,000	1,403	3	41	26	1,362
Catawba	3,250	2,080,000	31,894	1	58	14	31,836
Yadkin	9,300	5,952,000	36,004	51	4,822	47	31,181
Cape Fear	8,500	5,440,000	8,812	74	6,710	22	2,247
Neuse	4,450	2,848,000	3,219	29	972	21	2,199
Tar	3,075	1,968,000	670	7	287	9	383
Roanoke	3,375	2,160,000	22,524	10	990	7	21,534
Chowan	1,175	752,000	2,185	10	1,964	1	221
Broad River	1,450	928,000	2,387	0	0	4	2,387
Drain to S. Car.	200	128,000	820	6	820	0	0
New River to Watauga	980	627,200	40	1	40	0	0
Coastal Area	8,395	5,372,800	87,152	23	87,152	0	0
C. A. Sounds	3,212	2,055,680	2,055,680	0	0	0	0
TOTAL	52,712	33,735,680	2,284,848	198	103,740 Ac.	170	125,883 Ac.

CHAPTER IX - - GROUND WATER

Value of Ground Water - - Ground water is one of the most valuable resources in North Carolina. Approximately 2,800,000 people, or about 70 per cent of the total population of the State, depend upon ground water for their water supply. Probably more than 99 per cent of the rural population use water from wells, or springs, and approximately 500,000 people are supplied with ground water by municipalities and military establishments. Several million dollars are spent each year in obtaining this water supply, a large part of which is for drilling, boring, and digging new wells. Unfortunately, a considerable part of this money is spent unnecessarily because of a lack of adequate information on ground-water conditions.

Knowledge of Ground Water - - The ground-water resources of North Carolina are not fully known. Although much general information has been obtained since systematic studies were started in 1931 in accordance with cooperative agreements between the Director of the State Department of Conservation and Development and the Director, Geological Survey, U. S. Department of the Interior, whereby the Federal Government matches the funds provided by the State, considerable deficiencies in our knowledge of ground water resources still exist, especially with respect to specific locations.

The amount of water in storage in the underground reservoirs of North Carolina is enormous, exceeding the amount in the surface streams and lakes of the State. Many of our problems are concerned with providing information which will make possible the proper use of ground water. Greater use of ground water is being made for two reasons: (1) The ground water supply has been filtered and clarified by natural processes and is, therefore, usable without treatment, and (2) Surface water has been, and is being, misused to such an extent that a very large part of it can not be used for certain purposes at many locations.

Use of Ground Water - - Water obtained from beneath the surface of the earth has long been used as one of the principal supplies for direct consumption by man. Its popularity over surface water has been based largely on greater palatability and freedom of contamination. Rainfall is practically free of mineral matter. Ground water, however, often contains considerable mineral matter. As a result, it is evident that the quality of ground water is determined largely by the kind of rock through which the water moves and by the length of time during which it is in contact with the soil and rock.

The smaller communities and industries rely on ground water to a much greater degree than on surface water where small supplies are sufficient and the ground water reservoirs can yield a dependable supply, because the cost of surface intakes, filter plants, and other necessary facilities is greater than that of wells.

Relation of Precipitation to the Water Table - - In North Carolina a relationship exists between ground water levels and precipitation. This relationship is not a simple one, because factors other than precipitation and percolation affect the water levels. Most of the wells are far removed from pumping wells, and the changes in their water levels are due to natural causes. Water levels in the Coastal Plain generally respond much more quickly to rainfall than wells in the Piedmont Region, because the water table is

generally closer to the surface and the surficial deposits are more permeable in the Coastal Plain. With normal precipitation, the cycle of water table fluctuations begins with a gradual rise, starting usually in December or January. The level generally continues to rise until April or May, after which it begins to decline. The decline continues, interrupted only by rises of short duration caused by summer rainstorms, until the following December or January. The water table rises in late winter and spring, because very little water is lost by evaporation or is used by vegetation so that a relatively large part of the precipitation percolating into the ground reaches the water table. Although the amount of rainfall is larger during the summer months, the amount used by vegetation and lost by evaporation is so large that generally little or no rainfall reaches the water table.

One of the most important secondary contributions of ground water to our daily lives becomes evident in the summer and early fall months. During the late winter and early spring months, a considerable part of the precipitation soaks into the ground to fill up underground reservoirs where vast quantities of ground water may be stored. As these reservoirs become overfilled, the excess water drains out through springs and seeps, and finds its way into streams. Water moves slowly within the earth, and the draining process may continue for months. However, the greater the excess in the ground, the greater is the rate at which it will flow out of the ground. This ground-water discharge is one of the most important factors in maintaining the low-water flow in streams. During the periods when direct surface runoff from rainfall is small, it is the ground-water discharge that keeps the streams flowing.

Ground-water Investigations - - The need for greater knowledge of the changes in ground water levels, the effect of greater concentration of pumping, seasonal effects on water levels, and rates of replenishment of supplies led to systematic studies of ground-water resources. Data regarding the observation well-program under the Federal-State cooperative agreements referred to above are made available in annual publications by the U. S. Geological Survey titled "Water Levels and Artesian Pressures in Observation Wells in the United States, Part 2 - - Southeastern States."

The objectives of the observation-well program are (1) to provide a day-to-day evaluation of available ground-water supplies, (2) to facilitate the prediction of trends in ground water levels that will indicate the probable status of important ground-water supplies in the future, (3) to represent accurately present or potential areas of detrimentally high or low ground-water levels, (4) to aid in the prediction of the base flow of streams, (5) to determine the several forces that act on a ground-water body, (6) to furnish information for use in basic research, and (7) to provide long-term, continuous records of fluctuations of water levels in representative wells.

Ground-water investigations are concerned with the availability of usable water supplies, land drainage, flood control, construction of waterways and dams, mine drainage, and other problems to which the principles of ground-water hydrology are pertinent. Water levels in wells indicate the stages of aquifers; they show the extent to which water supplies are depleted by drought or by heavy pumping, and the extent to which water supplies are replenished in seasons of abundant rainfall or melting snow.

Water levels in wells are seldom stationary; they move up or down a

fraction of an inch or many feet within a short period of time. Water levels in wells may be influenced by direct recharge from precipitation, withdrawals from wells or springs, evapo-transpiration by vegetation, evaporation from the soil, and changes in atmospheric pressure.

Forty-six observation-wells were operated in North Carolina during 1951, from which water-level measurements were made. The locations of these wells are indicated on Map Plate, page 172, "Water Levels of Artesian Pressures, Geological Survey Water Supply Paper 1192".

North Carolina Topographic Regions - - The State of North Carolina extends from the Appalachian Mountain system to the Atlantic Ocean, being divided into three major topographic regions. These divisions are (1) the Coastal Plain on the east, (2) the Piedmont Plateau in the center, and (3) the Mountain Region on the west. From sea level on the eastern edge of the Coastal Plain, the topography rises in elevation and irregularity through the Piedmont Plateau and reaches maximum height and ruggedness in the Mountain Region.

The Coastal Plain includes slightly less than one-half of the area of the State and extends from the coast westward to an irregular line commonly known as the Fall Line. The Coastal Plain is divided into two natural parts, (1) an oceanward portion known as the Tidewater Region, which is low-lying, partly swampy, and poorly drained in many localities; and (2) an inner portion, which is gently rolling and in general well drained. The approximate boundary between the Tidewater Region and the inner portion is marked by a line drawn through the towns of Gatesville, Plymouth, Washington, New Bern, Jacksonville, and Wilmington. The eastern coast line is formed by a chain of long, narrow islands composed of sand dunes and beaches, from which Cape Hatteras, Cape Lookout, and Cape Fear project seaward toward the Atlantic Ocean. Between this chain of islands and the mainland is a vast inland sea, of shallow, salty water and connected by inlets to the Atlantic Ocean. This inland sea comprises approximately 2,360 square miles.

Most parts of the Coastal Plain will yield large quantities of water from wells. Supplies of several million gallons per day can be obtained from many places, and reasonable supplies for industrial uses can be obtained at almost any place in the Coastal Plain, except along the western margin. A goodly number of wells have been drilled that tested 1000 gallons or more per minute. Many others have been drilled which tested 300 to 400 gallons per minute with little or no drawdown and would doubtless yield several times their tested capacity.

The Piedmont Plateau consists of about two-fifths of the area of the State between the Coastal Plain and the Mountain Region. The elevation of its eastern border is 300 to 400 feet above sea level and rises gradually at the rate of about three to four feet per mile to an elevation of 1500 to 2000 feet at the foot of the Blue Ridge escarpment. The topography of this region consists of well-rounded hills and low-rolling ridges having a general Northeast-Southwest trend. The western portion of the Piedmont Plateau becomes more rugged as the Mountain Region is approached.

In the Piedmont Plateau are located the most thickly populated and highly industrialized areas of the State. Thousands of wells have been drilled in this area, and millions of gallons of ground water are used daily.

The Mountain Region is a highly dissected plateau, bounded by two mountain chains, on the east by the Blue Ridge Mountains, which rise as an escarpment 1500 to 2000 feet above the Piedmont Plateau, have a general elevation of 3,000 to 4,000 feet through Grandfather Mountain, and attain nearly 6,000 feet in some places; and on the west by several ranges, the most prominent of which is the Great Smoky Mountains, which form the boundary between North Carolina and Tennessee. Several of the peaks reach and exceed 6,000 feet.

Not much information is available regarding ground-water supplies and conditions in the mountainous section of the State. This is due to the fact that surface supplies have generally been readily available in this area. Ground water has certain advantages, such as constant supply and temperature, and is preferred at many places.

Wells in the Mountain Region vary in yield from 0 to 150 gallons per minute. The average yield of industrial and municipal wells in this section varies between 50 and 65 gallons per minute. The yield of home and farm wells will generally be considerably less, due to smaller size and shallower depths.

Hydrological Unit - Areas - - On the basis of the hydrologic properties of the underlying rocks, the Mountain Region and Piedmont Plateau have been divided into five hydrological unit-areas. Each of these unit-areas has several different kinds of rocks which are more or less similar in their geology and water-bearing properties. The Coastal Plain has been divided into four hydrological unit-areas, each of which differs from the others in its geology and water-bearing properties. The locations, kinds of rocks, water-yield, and water qualities of these hydrological unit-areas are shown on a map which is an appendix to "State Bulletin 47, Progress Report on Ground Water in North Carolina". Information regarding ground water in the Halifax, Greensboro, Charlotte, and Statesville Areas are contained in State Bulletins 51, 55, 63, and 68, respectively.

Hydrological Unit-Area No. 1

Location -- Currituck, Camden, Pasquotank, Perquimans, Chowan, Dare, Tyrrell, Washington, Hyde, and Pamlico Counties; the greater part of Beaufort County and the northeastern part of Craven County; and the smaller parts of Gates, Hertford, Bertie, and Martin Counties.

Kinds of Rocks -- Sand and clay with shells, shell rock and marl.
Yield ---Large amounts of water from wells 100 to 400 feet deep.
Quality--Water is hard, at places containing objectionable iron. Deeper water is brackish.

Hydrological Unit-Area No. 2

Location -- Cartaret and New Hanover Counties; most of Craven County south of Pamlico River and Pamlico Sound; the larger and eastern parts of Jones and Onslow Counties; the smaller and eastern part of Pender County; and the greater and oceanward part of Brunswick County.
Kinds of Rocks--Sand, clay, shell rock, marl, and limestone.
Yield ---- Very large amounts of water available in most parts. Wells yield up to 1000 gallons per minute.
Quality---Water usually hard. Brackish water at depths of 200 to 600 feet below the surface.

Hydrological Unit-Area No. 3

Location -- Hertford, Edgecombe, and Pitt Counties; the western and larger parts of Gates, Bertie, and Martin Counties; small sections of the western parts of Beaufort and Craven Counties; the northern and larger part of Greene County; small sections of the northeastern parts of Lenoir and Wayne Counties; and the larger and eastern parts of Wilson and Northampton Counties.

Kinds of Rocks--Sand, clay, and marl.

Yield----Moderate amounts of water from sand lenses.
Quality---Water frequently hard.
Yield and Quality--Large amounts of soft water available except along western margin of the area. Yields of 300 to 600 gallons per minute at many places.

Hydrological Unit-Area No. 4

Location---Duplin, Bladen, Columbus, Robeson, Scotland, Hoke, Cumberland, and Sampson Counties; western and smaller part of Brunswick County; western and larger part of Pender County; small sections of the western parts of Onslow, Jones, and Craven Counties; all of Lenoir County except a small section of the northeastern part; the smaller and southern part of Greene County; all of Wayne County except a section of the northwestern part; the southern part of Johnston County; a small section in the eastern part and most of the southern part of Harnett County; the southeastern part of Moore County; and a small section of the eastern part of Richmond County.

Kinds of Rocks--Sand, clay, argillaceous sand, and sandy clay; some limestone and marl in eastern part of area.
Yield----Large quantity of water available except in extreme western part. Yields of 500 gallons per minute possible at most places.

Quality---Water soft, low in dissolved solids, sometimes high in iron.

Hydrological Unit-Area No. 5

Location -- A belt, varying in width from 5 miles to 20 miles and extending from approximately the center of Granville County to the intersection of the boundary between Union and Anson Counties with the boundary between the States of North Carolina and South Carolina.

Kinds of Rocks---Sandstone, shale, mudstone, conglomerate, rarely limestone commonly lenticular, cross-bedded, arkosic. Rocks are bedded, dip horizontal to 45 degrees.

Yield----Small supplies of water, 5 to 25 gallons per minute, at most places. Moderate supplies, 25 to 100 gallons per minute, in some places.

Quality---Water generally moderately hard to very hard, sometimes contains objectionable amounts of iron.

Hydrological Unit-Area No. 6

Location -- A small section of the NW part of Vance County
A small section of the NW part of Wake County
A larger section of the NE part of Granville County
A small section of the northern part of Lee County
Eastern parts of Lee, Moore, and Richmond Counties
Most of Montgomery, Stanly, and Union Counties
The NW part of Moore County
The eastern and smaller part of Cabarrus County
The SE part of Rowan County
All of Randolph County
Most of Chatham County
The southern part and the SE section of the northern part of Alamance County
Most of Orange County
The eastern and larger part of Person County.

Kinds of Rocks--Schists, phyllites, slates, shales, and metamorphosed volcanics. In part of igneous and in part of sedimentary origin.
Yield----Generally moderately small to moderate, 10 to 50 gallons per minute. Occasionally moderately large supplies, to 300 gallons per minute.
Quality--Water frequently contains objectionable amount of iron.

Hydrological Unit-Area No. 7

Location--Parts of Stokes, Yadkin, Iredell, Forsyth, Catawba, Lincoln, Gaston, Cleveland, Surry, Wilkes, Caldwell, Burke, McDowell, Watauga, Avery, Haywood, Jackson, Macon, and Clay Counties.
The greater parts of Davie and Swain Counties.
All of Graham and Cherokee Counties.

Kinds of Rocks--Albite-chlorite schist, quartzite, slate, shale, and limestone. Chiefly derived from sedimentary formations. Bedding usually distinct.
Yield----Generally moderate supplies of water. Wells yield from 5 to 50 or more gallons per minute. Water usually soft, except from wells in limestone.

Hydrologic Unit-Area No. 8

Location---Parts of Caswell, Rockingham, Guilford, Forsyth, Stokes, Surry, Yadkin, Swain, Macon, Clay, Madison, Avery, Mitchell, Henderson, Transylvania, Catawba, Lincoln, Cleveland, Wilkes, Allegheny, Ashe, and Caldwell Counties. The greater parts of Jackson, Haywood, Yancey, Buncombe, and Iredell Counties.
Kinds of Rocks--Gneiss and schist, chiefly feldsparbiotite, gneiss, and schist included in the Carolina gneiss.
Yield----Moderate to moderately large amounts of water. Industrial and municipal wells average about 50 gallons per minute. Best supplies obtained in coarser phases where dip is fairly low.

Quality---Water soft to moderately hard.

Hydrologic Unit-Area No. 9

Location--Parts of Vance, Granville, Johnston, Durham, Orange, Chatham, Person, Alamance, Guilford, Davidson, Davie, Yadkin, Wilkes, Alexander, Catawba, Cleveland, Wilkes, Caldwell, Burke, McDowell, Transylvania, Ashe, Watauga, Avery, Mitchell, Yancey, Buncombe, Madison, and Haywood Counties. The greater parts of Wake, Harnett, Franklin, Warren, Rowan, Cabarrus, Rutherford, and Henderson Counties. Practically all of Mecklenburg and Polk Counties.

Kinds of Rocks--Cranberry granite, Henderson granite, Blowing Rock gneiss, Bessemer granite, Whiteside and Yorkville granites, and similar rocks of igneous origin.

Yield----Generally small, sometimes moderate, rarely moderately large supplies of water. Best supplies are from more highly metamorphosed rocks. Only a few gallons per minute from wells in unsheared rocks.

Quality---Moderately soft to hard.

CHAPTER X - - QUALITY OF WATER

Impurities in Rainwater - - Among all the constituents of the atmosphere, aqueous vapor is the most variable in amount and most important geologically. Aqueous vapor dissolves and concentrates the other ingredients of the air and brings them to the ground in rain. Some moisture is always present in the air, and, when it condenses to rain, it absorbs oxygen, nitrogen, carbon dioxide, and other gases, and forms weak acids and other chemical compounds.

When rain falls upon the surface of the earth, it brings with it the impurities noted above. This rainwater contains carbonic acid in solution, and that impurity increases its solvent power, particularly with regard to limestones. The moment the water leaves the atmosphere and enters the porous earth, the chemical and solvent activities of water begin and continue, probably without interruption, until it reaches the ocean. The character and extent of the work thus done varies with local conditions, such as temperature and the nature of the earth materials encountered. These actions also bring about changes in the water which will vary from time to time and place to place, thus affecting the chemical characteristics of the waters in streams, lakes, and in the ground. The quality of the water recovered from the ground depends on geological conditions, such as the chemical composition of the water-bearing deposits, and formations and minerals associated with water-bearing rocks. The quality is also affected by the source of the ground water, the rate at which the water is moving through the rocks, and the amount of recharge from the surface.

Characteristics of Surface Waters - - Chemical and physical characteristics of surface waters are quite variable. They vary from time to time and place to place. The conditions which cause these variations are chemical, geologic, climatic, and cultural. Surface waters vary in chemical and physical characteristics between times of flood and times of drought, and their composition is changed by the influx of tributaries. It is also modified by seepage from the river banks, and the additions to the hardness of river water from this source may be considerable. Where ground waters contribute largely to the flow of a stream, the resulting surface waters will have much of the same qualities of the ground waters themselves. Where direct precipitation is the largest factor contributing to surface waters, the mineral content thereof will be much less and the total hardness will be lower.

Qualities Required for Domestic and Industrial Use - - For domestic consumption, soft, clear, palatable water is desirable. Industrial requirements may vary from nearly 100 per cent purity to very low degrees of quality. Most emphasis is placed upon the impurities that water should not contain.

Hardness is probably the most common of the objectionable qualities. Chemically, hardness is caused by compounds of calcium and magnesium present in water. It is objectionable in the home because of its soap-consuming capacity. It is recognized by the quantity of soap required to produce a lather and by the formation of an insoluable curd which is objectionable in all washing processes. For economical and satisfactory operation, commercial laundries require soft water. Hard water is not satisfactory for many industrial processes such as in the bleaching, dyeing, rayon, high grade light paper, and soap industries. Particularly, hard water is objectionable because of the formation of scale in boilers, water heaters, radiators, and pipes, with the resultant loss in heat transfer, boiler failure, and loss of flow.

Water softening is the most common type of treatment applied by industrial plants. Some industries require the removal of other minerals in addition to calcium and magnesium if the water is to be used in processing products. Only a very small per cent of industries, however, complete demineralization of water.

Industries manufacturing food, carbonated beverages, beer, textiles, dyed fabrics, high-grade paper, and ice must have water practically free from iron. Boiler feed water must be of high quality with a low content of silica, calcium, magnesium and soft sulfates. Water which is used in, or comes in contact with, manufactured products may have to meet specific requirements.

Temperature is also an important quality and is becoming of increasing economic importance particularly in cooling processes. More than half of the water used by industry is used for cooling purposes alone.

Investigation of Chemical Character -- Information on the chemical character of surface waters is necessary for adequate industrial development and planning. It is essential to the locating of many industries and to a better and more economical use of water by both industries and municipalities. Knowledge of the chemical character of surface waters is needed for planned coordination in the most advantageous use of water for industry, public supply, agriculture, and recreation, and in the conservation of fish and wildlife. Investigation of the chemical character of surface waters in North Carolina was begun in 1943 by the Geological Survey of the United States Department of the Interior in cooperation with the North Carolina Department of Conservation and Development. The results of chemical analyses for 46 daily stations, 24 monthly stations, and of miscellaneous streams throughout the State during the period from October 1, 1944 to September 30, 1952, inclusive, are published in Bulletin 52, Volumes 1 to 8, inclusive, North Carolina Department of Conservation and Development. During the water year October 1946 to September 1947, for example, samples were collected daily at six points and monthly at four points on streams in North Carolina. Spot samples were collected in the river basins throughout the State. All of the daily and monthly samples, as well as a considerable number of the spot samples, were collected at or near gaging stations. The temperature of the water was measurered daily at the points at which daily samples were collected.

The daily samples were collected in 12-ounce bottles and were poured into gallon bottles to make three composite samples per month. The monthly and the spot samples were collected in gallon bottles.

The samples were filtered through fine, diatomaceous-filter cylinders and analyzed in accordance with methods regularly used by the United States Geological Survey.

Suitability of Water -- Water of good quality, and available in sufficient quantity, is a highly valuable asset. Much of North Carolina's prosperity is directly related to the availability and quality of water supplies. An adequate water supply is a determining factor in the selection of an industrial site. Sharing importance with quantity is a knowledge of chemical composition and degree of pollution.

The suitability of water for man's needs is dependent on its sanitary and chemical qualities. Basically, water is composed of one part of oxygen and two parts of hydrogen. However, the sanitary engineer, the water-works engineer, the chemist, and others think of water as a solvent, which contains other elements than hydrogen and oxygen. Water may have many mineral constituents dissolved in it, including calcium, magnesium, iron, fluroide, and chloride. The amount of mineral matter may or may not limit the use of water. For example, one industry may require a water which is practically free of one or more mineral constituents, while another industry may be able to use water which contains comparactively large amounts of minerals.

Limits of Tolerance -- Many users of water have established limits of tolerance for each constituent in water In those industrial processes involving direct contact between water and the product, water containing very small amounts of iron

and manganese is generally required. If the concentration of iron and manganese, either separately or together, exceeds three-tenths of a part per million, a brownish stain will in all probability form on the product. Small amounts of calcium and magnesium are highly desirable in order to avoid the deposition of a sticky, jelly-like, or solid mass on the product. In boiler and turbine operation, the presence in water of hardness, sulfates, and silica in large amounts are very detrimental, because they cause hard scale and deposits. The beverage and canning companies require a water which does not adversely affect the taste and quality of the product. Consequently, these industries cannot use water containing large quantities of sodium, iron, manganese, bicarbonates, sulfates, and chlorides. The water requirements of other industries may demand similar or more exacting standards. Determination of the chemical quality of water affords a basis for judging whether a water is of good or poor quality.

The requirements for a public supply are fulfilled by a water of good quality. In industry, the temperature of the water is an additional requirement that must be considered, especially where water is needed for cooling. A water of poorer quality and more suitable temperature in some instances is more desirable than one of superior quality and undesirable temperature. Generally, the temperature of surface water is more variable than that of ground water and is more affected by changes in air temperature.

In obtaining knowledge of the chemical quality of waters through analysis of samples thereof, certain determinations are made and accepted descriptive terms are used. Some of these determinations and terms are set forth below.

Hardness. Physically, hardness is evidenced by the amount of soap required to produce a lather and by the formation of an insoluble, curd like substance. Soft water forms a lather readily. Chemically, hardness is caused for the most part by the calcium and magnesium present in water. In terms of numerical values, waters having hardnesses as set forth below would be classified as indicated.

60 parts per million or less---------Soft

61-90 parts per million-------------Slightly hard

91-120 parts per million------------Moderately hard

Over 120 parts per million----------Hard

Conductivity. Another characteristic of water is its ability to conduct an electric current. The amount of current varies with the concentration and degree of ionization (conversion into electrified particles) of the constituents in solution, and the temperature. In water analysis, specific conductance measurements are expressed in units of micromhos at a specified temperature, usually 25 degrees Centigrade. This measurement is sometimes useful in estimating the total concentration of mineral matter in solution. A high specific conductance generally indicates a greater concentration of dissolved mineral matter than a lower value.

PH. Hydrogeon-ion concentration of water expressed as PH is a measure of its acidity or alkalinity (having sharply painful taste and ability to neutralize acids). Water having a PH value of 7 is considered neutral, i. e., neither acid nor alkaline. The greater the PH value of water above 7, the greater is its alkalinity, and the smaller the PH value of water below 7, the greater is its acidity.

Suspended Matter. This term covers the undissolved material in water which usually gives a stream a muddy or cloudy appearance, depending on the kind of material in suspension. The amounts of suspended matter vary throughout the year and usually increase and decrease with amount and intensity of rainfall. Values for suspended

matter only approximate the true concentrations of sediment in surface water at the time of collection of the sample.

Color. Color in water is considered to be the visual effect due to material in solution and not that due to turbidity, or suspended material in the water. The color of surface waters varies with the regions through which the waters flow. Clear, colorless water is usually characteristic of mountain streams, whereas surface waters originating or flowing through swamps are highly colored due to the presence of organic matter in solution. The color of water for public water supplies shall not be greater than 20 according to the United States Public Health Service standards. In the industrial field, color may or may not be a critical factor. For example, in the manufacture of white bond paper and fine textiles, the process water must be practically colorless. On the other hand, there is a wider range in the manufacture of kraft paper, burlap, and other products.

Oxygen Consumed. This term constitutes an approximate measure of the amount of matter, capable of combination with oxygen, which is present in filtered and unfiltered samples of water. It does not distinguish between organic (pertaining to the compounds of carbon) and inorganic material. However, high values for oxygen consumed, when considered in connection with other determinations, will indicate the possible presence of large amounts of organic material in water.

Silica (SiO_2). Silica is dissolved from practically all rocks. Silica affects the usefulness of water because it contributes to the formation of boiler scale. It is practically troublesome in high-pressure boilers, since the hard scale prevents rapid transfer of heat, resulting in boiler-tube failure. It also forms deposits on the blades of steam turbines.

Iron (Fe). Iron is dissolved from many rocks and soils and frequently from the iron pipes through which the water flows. Iron in the water in the home is objectionable, because it makes stains on porcelain or enameled fixtures and on clothing and other fabrics. Preferably, water furnished to domestic consumers should not contain more than 0.3 part per million of iron. Many industries, including those for the manufacture of food, carbonated beverages, beer, textiles, dyed fabrics, high-grade paper, and ice, must have water practically free from iron.

Calcium (Ca) and Magnesium (Mg). Calcium is dissolved from practically all rocks. It is usually found in greater quantities in contact with limestone, dolomite, and gypsum. Calcium carbonate ($CaCO_3$) is appreciably soluble in waters containing carbon dioxide. It is only slightly soluble in pure water. Magnesium is dissolved from many rocks, particularly from dolomitic rocks. Sea water contains large quantities of magnesium. Calcium and magnesium make waters hard, and are largely responsible for the formation of boiler scale. Magnesium in water should not exceed 125 parts per million.

Sodium (Na) and Potassium (K). Sodium and potassium are dissolved from practically all rocks and soils. They usually make up only a small part of the dissolved solids in natural surface waters of North Carolina. Some polluting materials may noticeably increase the sodium content of the waters. As sea water is largely a solution of common salt (sodium chloride, NaCl), considerable quantities of sodium may be found in water in contact with sea water or in water that flows through areas containing sea salts. Natural waters that contain less than five parts per million of the two together are likely to carry almost as much potassium as sodium. As the total quantity of these constituents increases, the proportion of sodium becomes greater. Moderate quantities of sodium and potassium have little effect on the suitability of water for most purposes. Waters that

carry more than 50 to 100 parts per million may cause foaming in steam boilers. Some waters may contain so much sodium that they are unfit for most users.

Carbonate (CO_3) and Bicarbonate (HCO_3). Bicarbonate in natural waters results from the action of carbon dioxide (CO_2) in the water on carbonate rocks. Carbonate is not present in appreciable quantities in most natural surface waters, and it is not present in waters having a PH of less than about 8.3. Bicarbonate or carbonate is useful in coagulation of water for the removal of suspended matter. Bicarbonate is the principal anion (the negatively charged particle in an electrolyzed solution) of the natural surface waters in the Piedmont Plateau. Bicarbonate is usually present in smaller amounts in the regions of high altitude and in the colored waters originating in the Coastal Plain. A few of the colored waters, draining areas of marl and shellrock in the Coastal Plain, contain larger amounts of bicarbonate.

Sulfate (SO_4). Sulfate is dissolved from rocks and soils, and in large quantities from areas containing gypsum and deposits of sodium sulfate. It is also formed by the oxidation of sulfides and is therefore present in noticeable quantities in waters from mines. Sulfate in waters that contain calcium and magnesium causes the formation of hard scale in steam boilers and may increase the cost of softening or influence the choice of the method of softening the water. Sulfate in water supply systems should not exceed 250 parts per million.

Chloride (Cl). Chloride is dissolved from rocks and soils. Natural surface waters in North Carolina are usually low in chloride. Waters in contact with sea water or sea salts are likely to contain considerable chloride, as sodium chloride is the abundant constituent of sea water. The chloride content of surface waters may be increased by pollution from sewage and some industrial wastes. Large quantities of chloride may affect the industrial use of water by increasing the corrosiveness of waters that contain large quantities of calcium and magnesium. The Public Health Service drinking-water standards indicate that preferably the chloride content of water furnished by water-supply systems should not exceed 250 parts per million.

Fluoride (F). Fluoride may be present in some rocks to about the same extent as chloride. It is present in much smaller quantities than chloride in most natural waters. Fluoride in water is associated with the dental defect known as mottled enamel, if the quantity of fluoride in water, used for drinking by young children during calcification or formation of the teeth, increases above one part per million. It is reported, however, that the incidence of dental caries (decay of teeth) is decreased by small quantities of fluoride, and that small quantities of fluoride in water are presumed beneficial when not sufficient to mottle the enamel during formation of the teeth. Natural surface waters in North Carolina rarely contain more than 0.4 part per million of fluoride. Waters having more than 1.5 parts per million of fluoride would have a harmful effect.

Nitrate (NO_3). Nitrate in water may indicate previous contamination by sewage or other organic matter, as it represents the final stage of oxidation in the nitrogen cycle. The quantities of nitrate usually present in surface waters have no effect on the value of the water for ordinary uses. It has been reported that sodium nitrate concentrations above a certain limit inhibit intercrystalline cracking of boiler steel. Since the nitrate is concentrated in the boiler, as little as two parts per million of nitrate in some feed waters may be sufficient to protect the boiler steel.

Dissolved Solids. The quantity reported as dissolved solids (the residue on evaporation) consists mainly of the dissolved mineral constituents in water. It may also contain some organic matter and water of crystallization. The quantity of dissolved solids is reported in parts per million and is determined by evaporation

a given quantity of water and weighing the residue after it has been dried at 180 degrees C. for one hour. In the evaporation of the water the bicarbonate is changed to carbonate as carbon dioxide is driven off. In computing the sum of the mineral constituents for comparison with the dissolved solids, it is necessary to convert the bicarbonate to carbonate. The dissolved solids of the surface waters of North Carolina will vary throughout the year. Water containing less than 500 parts per million of dissolved solids generally are satisfactory for most domestic and industrial uses. Waters with more than 1,000 parts per million of dissolved solids are likely to contain certain constituents that make them unsuitable for domestic or industrial uses.

CHAPTER XI - - ABATEMENT OF STREAM POLLUTION

Pollution-abatement Legislation - - The General Assembly of North Carolina, on April 6, 1951, ratified an act to rewrite Article 21 of Chapter 143 of the General Statutes relating to stream sanitation. This act contains a declaration of policy as follows: It is hereby declared to be the policy of the State that the water resources of the State shall be prudently utilized in the best interest of the people. To achieve this purpose, the government of the State shall assume responsibility for the quality of said water resources. The maintenance of the quality of the water resources requires the creation of an agency, charged with this duty and authorized to protect the water requirements for health, recreation, fishing, agriculture, industry, and animal life. This agency shall establish and maintain a program, adequate for present needs and designed to care for the future needs of the State.

The State Stream Sanitation Committee - - The act created within the State Board of Health a permanent committee, to be known as the "State Stream Sanitation Committee", which shall be composed of eight members as follows: The Chief Engineer of the State Board of Health, ex-officio, the Chief Engineer of the Division of Water Resources, Inlets, and Coastal Waterways, Department of Conservation and Development, ex-officio, and six members appointed by the Governor. Of these six members, one shall at the time of appointment be actively connected with and have had production experience in the field of agriculture, one shall at the time of appointment be actively connected with and have had experience in the wildlife activities of the State, two shall at the time of appointment be actively connected with and have had practical experience in waste disposal problems of municipal government, and two shall at the time of appoint ment be actively connected with and have had industrial production experience in the field of industrial waste disposal. Ex-officio members shall have all the privileges, rights, powers, and duties held by appointed members except the right to vote.

The duties of the Committee are (1) to develop and adopt classifications of State waters, (2) to survey all waters and identify those which ought to be classified, (3) to assign a classification to each identified water, and (4) to hold public hearings regarding assigned classifications.

Control of New Sources of Pollution - - After the effective date of the assignment of classifications pertaining to the indentified waters of any watershed within the State, no person shall, to an extent which would adversely affect the condition of the receiving water within such watershed in relation to any of the standards applicable to such water, (1) make any new outlet into the waters of such watershed, (2) construct or operate any new disposal system within such watershed, (3) alter or change the construction or the method of operation of any existing disposal system within such watershed, (4) increase the quantity of sewage, industrial waste, or other waste discharged through any existing outlet or processed in any existing disposal system, or (5) change the nature of the sewage, industrial waste, or other waste discharged through any existing outlet or processed in any existing disposal system.

Powers of the Committee - - The Committee has the following powers as to permits to make new outlets, construct or operate new disposal systems, alter or change the construction or method of operation of existing disposal systems, or to increase the quantity or change the nature of wastes discharged:

a. To grant a permit with such conditions attached as the Committee believes necessary to achieve the purposes of control of new sources of pollution;

b. To grant any temporary permit for such period of time as the Committee shall specify, even though the action allowed by such permit may result in pollution or increased pollution, where conditions make such temporary permit essential; and

c. To modify or revoke any permit upon not less than 60 days' written notice to any person affected.

The act sets forth procedures as to applications and permits, and as to hearings and appeals in connection with action on applications. It provides that the Committee may issue special orders directing any person responsible for pollution to take action to alleviate or eliminate pollution, that no person shall discharge waste in violation of a special order issued by the Committee, that no special order shall be issued except after hearing unless the person affected thereby consents, and that the person against whom a special order is issued shall have the right to appeal.

The act provides that the Committee shall encourage voluntary action in remedying pollution situations. Any person may submit to the Committee proposed plans for installation of treatment works for approval. The Committee shall make thorough investigations of proposed plans for volumtary action, shall have the power to issue certificates of approval of such plans, may specify further rules applicable to granting of certificates, and shall have power to entertain, and act on, applications for modification of any certificate of approval.

The Committee has the following general powers in addition to the specific powers prescribed elsewhere in the act:

a. To adopt, modity, and revoke official rules of procedure.

b. To conduct such investigations as it may deem necessary to carry out its duties.

c. To conduct public hearings.

d. To delegate its powers to one or more of its members or to one of its qualified employees.

e. To initiate actions in the appropriate Superior Court.

f. To agree upon and enter into settlements or compromises and to prosecute appeals or other proceedings.

g. To conduct scientific experiments, research, and investigations.

h. To cooperate and enter into contracts with State agencies, institutions, muncipalities, industries, and other persons.

i. To act in cooperation with the State Board of Health in local administration of Public Law 845, passed by the Congress in 1948, and future legislation by the Congress relating to water quality. (This law authorized the Surgeon General of the Public Health Service, upon request of any State water-pollution agency or interstate agency, to conduct investigations and research and make surveys concerning any specific problem of water pollution confronting any State, interstate agency, community, municipality, or industrial plant, with a view to recommending a solution of such problem; authorized the Federal Works Administrator to make loans to any state, municipality, or interstate agency for the construction of necessary treatment works; authorized appropriations to the Federal Security Agency to be allotted equitably and paid to the States and to interstate agencies for expenditure by them for investigations,

research, surveys, and studies related to prevention and control of water pollution caused by industrial wastes; and authorized appropriations to enable the Federal Works Administrator to make grants to States, municipalities, or interstate agencies to aid in financing the cost of investigations and action preliminary to construction approved by the appropriate State water pollution agency or agencies and by the Surgeon General of the Public Health Service.)

j. To consult with qualified representatives of adjoining States.

Regulations, Rules, Hearings, and Judicial Review -- The act provides that the Committee shall codify its regulations and rules, and from time to time shall revise and bring up to date such codifications, and that its hearings shall be held upon not less than 30 days written notice and shall be open to the public. The following provisions are applicable in connection with the Committee's hearings:

a. Full and complete records shall be made.

b. Insofar as practicable, procedures applicable in civil action in the Superior Court shall be followed.

c. Action with regard to subpoenas shall be in accordance with procedures and rules of law.

d. The burden of proof shall be upon the Committee or upon the person at whose instigation the hearing is held.

e. The decision or order of the Committee must be supported by appropriate evidence.

f. The Committee shall afford opportunity for presentation of findings of fact, conclusions of law, and briefs.

g. Committee orders and decisions shall set forth findings of fact and conclusions of law.

The act provides for judicial review of the final orders and decisions of the Committee, indicates actions which constitute violations, and sets forth penalties for violations.

PROGRESS TOWARD ABATEMENT OF STREAM POLLUTION

1. Yadkin River Basin -- All of the work in this basin, including the detailed studies, preparation of a comprehensive report, and the holding of public hearings regarding the classification of the basin waters, has been completed.

2. White Oak River Basin -- All detailed field investigations and stream sampling work have been completed, and the comprehensive report, as of November 1, 1954, was about three-fourths completed. The completion of the report, the holding of public hearings, and the assignment of classifications to the basin waters remain to be accomplished before a comprehensive pollution abatement program can be carried out.

3. Chowan River Basin -- The necessary field studies, including plant investigations, stream sampling, and land and water use studies, have been completed. The comprehensive basin report, as of Novenber 1, 1954, was about one-fourth completed. The completion of the report, which should be accomplished by July 1, 1955, the holding of public hearings, and the assignment of classifications to the basin waters remain to be done before a comprehensive pollution abatement program can be initiated.

4. Roanoke River Basin -- Field and laboratory studies for the entire basin have been completed. A preliminary report, prepared by the Public

Health Service, has been completed for that portion of the river below the John H. Kerr Reservoir, and several conferences have been held relating to the effects of water releases at the Kerr Reservoir upon the striped bass fishery below Roanoke Rapids and Weldon. As a result of these conferences, the North Carolina Wildlife Resources Commission, on December 13, 1954, transmitted to the District Engineer, Norfolk, District, Corps of Engineers, U. S. Army, recommendations regarding flows which should be available in the vicinity of Roanoke Rapids and Weldon during the striped bass spawning season in 1955 in order to protect this highly valuable fishery. The preparation of the comprehensive river basin report, the holding of public hearings, and the assignment of stream classifications to bhe basin waters must be completed prior to initiating a basin-wide pollution-abatement program. The report, public hearings, and classification of the streams in this basin should be completed during the calendar year 1955.

5. French Broad-Pigeon Basin - - The stream sampling program has been completed, and the laboratory data have been calculated and compiled. Remaining to be completed are studies of the significant sources of pollution, land and water uses, and the preparation of the comprehensive basin report. It is believed that this work will be completed by August 31, 1955.

6. Cape Fear River Basin - - The studies during the summer of 1954 were restricted to the upper portion of the Cape Fear River Watershed, which includes the Haw and Deep Rivers and their tributaries down to the point where they join to form the Cape Fear River. All routine samplings on these streams and their tributaries, necessary routine investigations of significant sources of pollution, water and land uses, etc., have been completed. Data regarding laboratory and field findings are being compiled, and special studies of major sources of pollution, which will continue during the winter of 1954-1955, have been started. Remaining to be studied is that portion of the basin below the confluence of the Haw and Deep Rivers. Completion of studies in this basin will require another full year for accomplishment. It is believed that preparation of the comprehensive river basin report, and the holding of public hearings on proposed assignment of stream classifications to the basin waters, will be completed during the calendar year 1956.

7. Neuse River Basin - - The stream sampling work in this basin was initiated about July 15, 1954, and was continued until the temperature of the water in the streams dropped below 15 degrees centigrade. Routine sampling in the main stem and all tributaries above Milburnie near Raleigh were practically completed as of November 1, 1954. Field surveys to determine exact data regarding the location and character of significant sources of pollution, water and land uses, and other pertinent information were then being conducted. Remaining to be completed is that portion of the basin below Raleigh. It is estimated that this work will be completed by August 31, 1955 and that the preparation of the comprehensive river basin report, and the report on public hearings on proposed assignment of stream classifications to the basin waters, will be completed during the calendar year 1956.

Evaluation of the Stream Pollution Program of the Committee - - As of November 1, 1954, all work, including the holding of public hearings necessary to assigning classifications, had been completed for 13.73 per cent of the area of the State; detailed river basin studies had been completed, and comprehensive reports were under preparation, covering another 20.26 per cent of the area of the State; and detailed studies were approximately one-half completed in additional river-basins comprising 32.51 per cent of the area of the State. Studies had been completed or were under way on watersheds comprising a total area equal to two-thirds of the entire area of the State.

Public hearings regarding proposed classifications and water quality standards for North Carolina were held during 1953 at Asheville, Charlotte, Greensboro, Fayetteville, and Washington on July 28, July 30, August 11, August 13, and August 18, respectively.

Yadkin River Basin - - The Yadkin River Basin Pollution Survey Report No. 1, presenting information regarding stream conditions, usage of the water resources in the basin, sources of pollution entering these water resources, pollution prevention measures then in effect, and proposed classifications for the waters of the basin, was published in 1953. Public hearings regarding proposed classifications for the waters of this basin were held during 1954 at Winston-Salem, Rockingham, and Concord on June 8, 10, and 18, respectively. The Committee, at their meeting on December 14, 1954, upon completion of hearings and consideration of submitted evidence and arguments with respect to any proposed action of the Committee pursuant to the law relating to stream sanitation, effected final adoption and assignment of classifications to the waters of the Yadkin River Basin and directed the publication of such final action. The Committee likewise directed the publication, as part of its official regulations, of the effective date of the provisions of Section 143-215.1 (Control of New Sources of Pollution) and Section 143-215.2 (Abatement of Existing Pollution) of the General Statutes of North Carolina to be April 6, 1955, the fourth anniversary of its creation by Chapter 606, Session Laws of 1951, General Assembly of North Carolina.

The Committee have established classifications and the standards applicable to each such classification, which will be appropriate for the purpose of classifying each of the waters of the State in such a way as to promote most effectively the policy and purposes of the Act which created the Committee. These classifications are as follows:

Established Classes for Fresh Surface Waters

Class A-I

Best Usage of Waters: Source of water supply for drinking, culinary, or food-processing purposes, or any other usage requiring water of lower quality.

Conditions Related to Best Usage: This class is intended primarily for waters having watersheds which are uninhabited and otherwise protected as required by the State Board of Health and which require only approved disinfection, with additional treatment when necessary to remove naturally present impurities, in order to meet the "Public Health Service Drinking Water Standards" and to be considered safe for drinking, culinary, and food-processing purposes.

Class A-II

Best Usage of Waters: Source of water supply for drinking, culinary, or food-processing purposes and any other best usage requiring waters of lower quality.

Conditions Related to Best Usage: The waters, if subjected to approved treatment equal to coagulation, sedimentation, filtration, and disinfection, with additional treatment if necessary to remove naturally

present impurities, will meet the "Public Health Service Drinking Water Standards" and will be considered safe for drinking, culinary, or food-processing purposes.

Class B

Best Usage of Waters: Bathing and any other usage except as source of water supply for drinking, culinary, or food-processing purposes.

Conditions Related to Best Usage: The waters, under proper sanitary supervision by the controlling health authorities, will meet accepted standards of water quality for outdoor bathing places and will be considered satisfactory for bathing purposes. In the absence of the sanitary supervision required for bathing purposes, these same waters will be suitable for boating, camping, scenic purposes, and other recreational uses and will be so classified where, in the opinion of the Committee, their geographic location, appearance, condition, and present or potential usage will justify such classification. The waters will be suitable for other uses requiring waters of lower quality.

Class C

Best Usage of Waters: Fishing and any other usage except for bathing or as a source of water supply for drinking, culinary, or food processing purposes.

Conditions Related to Best Usage: The waters will be suitable for fish and wildlife propagation, and for other uses requiring water of lower quality.

Class D

Best Usage of Waters: Agriculture, industrial cooling and process water supply, fish survival, and any other usage, except fishing, bathing, or as source of water supply for drinking, culinary, or food-processing purposes.

Conditions Related to Best Usage: The waters, without treatment and except for natural impurities which may be present therein, will be suitable for agricultural use and for industrial and process cooling waters, and, with special treatment as may be needed under each particular circumstance, will be satisfactory for other industrial processes and will permit fish survival.

Class E

Best Usage of Waters: Navigation and any other best usage, except agriculture, source of industrial cooling or process water supply, fishing, bathing, or source of water supply for drinking, culinary, or other food-processing purposes.

Conditions Related to Best Usage: Waters will be suitable for navigation, and, in certain instances where there is either no practical means of treatment known or where the degree of treatment required to satisfy the standards for a higher degree is economically impractical, these waters may be used for the disposal of sewage, industrial wastes, or other wastes until feasible treatment processes become available. Any such usage, however, shall in no instance result in the development of a nuisance.

Established Classes for Tidal Salt Waters

Class SA

Best Usage of Waters: Shellfishing for market purposes and any other usage requiring waters of lower quality.

Conditions Related to Best Usage: The waters will meet the sanitary and bacteriological standards given in the latest edition of "Manual of Recommended Practices of Sanitary Control of the Shellfish Industry", recommended by the Public Health Service, and will be considered safe and suitable for shellfish culture.

Class SB

Best Usage of Waters: Bathing and any other usage except shellfishing for market purposes.

Conditions Related to Best Usage: The waters, under proper sanitary supervision by the controlling health authorities, will meet accepted sanitary standards of water quality for outdoor bathing places and will be considered safe and satisfactory for bathing purposes.

Class SC

Best Usage of Waters: Fishing, and any other usage except bathing or shellfishing for market purposes.

Conditions Related to Best Usage: The waters will be suitable for fishing, fish propagation, and for other uses requiring waters of lower quality.

Class SD

Best Usage of Waters: Navigation and any other best usage, except fishing, bathing, or shellfishing for market purposes.

Conditions Related to Best Usage: The waters will be suitable for navigation, and, in certain instances where there is either no practical means of treatment known or where the degree of treatment required to satisfy the standards for a higher class is economically impractical, these waters may be used for the disposal of sewage, industrial wastes, or other wastes until feasible treatment processes become available. Any such usage, however, shall in no instance result in the development of a nuisance.

Quality Standards - - The Committee have set forth in their Regulation No. I quality standards for each of the ten classes indicated above, including specifications for floating solids, settleable solids, sludge deposits, tastes, odor-producing substances, sewage and waste effluents, toxic wastes, oils, deleterious substances, colored or other wastes, phenolic compounds, pH, total hardness, dissolved oxygen, heated liquids, and organisms of coliform group.

Land-use Practices -- The rate at which water will run off land is affected greatly by the covering vegetation and practices in tilling the soil. Water running off at a rapid rate concentrates in the streams quickly and carries with it considerable quantities of soil. Rapid run-off and soil erosion result in damaging floods and sedimentation downstream.

Through proper land-use practices, soil erosion and run-off from the land can be reduced, thereby causing substantial reductions in floodwater and sediment damage and preserving fertility. Infiltration rates can also be increased to place more water in the soil to be available for plant use during dry periods.

Proper land-use practices may include such measures as strip cropping, contouring, terracing, stabilizing and sediment control structures, and upstream floodwater retarding structures.

Strip cropping is the use of alternate meadow crops with either clean-tilled or small grain crops in contoured lands on a hillside.

Contouring consists of farming land on the level, or plowing and planting along lines of equal elevation on a slope.

Terracing consists of breaking a long slope into a series of short, flat or slightly sloping steps to reduce the velocity with which free water moves over the surface of the ground. The use of soil treatment and cultural practices adapted to the field will allow only a minimum of run-off water to attain scouring velocity.

Stabilizing and sediment control structures are earth or masonry dams used in stabilizing waterways by temporarily impounding run-off water and discharging it slowly. These structures reduce inundation damage, gully erosion, and sediment damage below the structure site.

Upstream floodwater retarding structures are dams located on headwater streams and furnish protection for flood-plain areas by providing temporary storage for run-off.

While these land-use practices do not eliminate all floods, they are very useful in reducing damage to the land and in making other measures downstream more effective and of longer life. The Soil Conservation Service, U. S. Department of Agriculture, and the North Carolina Soil Conservation Districts have done much work in this field.

Nature of Watersheds -- Everyone knows that water runs downhill. Far too little consideration, however, has been given to the ways in which water runs downhill. It can be destructive or beneficial, depending upon its quality, its volume, and the manner and time of its running.

Water is never a permanent part of any man's property. Even though he may catch it, store it, and use it, some or all of it will get away to resume its travels through the air or down a river. He may have a title or legalized right to a water use. Water itself and gravity, however, determine the truth that nobody can hold the title to any portion of water.

The amount of water we may have for our needs and how we may use it depends on nature's gigantic water-gathering mechanisms called watersheds. With every living soul dependent on water, the good or bad management of our watersheds is a very personal matter and a paramount public responsibility.

Every acre of land surface is in some sort of watershed. Little tributary basins gather waters that fall thereon to feed the flow of a little rill or very little brook. The rill or brook joins others from similar small basins to form a creek that joins another creek or two creeks or several creeks, forming a tributary river which finally joins a major stream. The rate at which the little watersheds feed water to the larger streams, or the period of time in which they deliver sky water out of their basins, determines the difference between a maintained flow over a long period or a flood crest downstream. Many of the same factors, entering into how rapidly a basin pours water into rills and creeks, determine the quantity and quality of water in lower channels and the degree and type of use which can be made of that water at any point in transit. The first step in proper management of the water resource starts at the height of land between drainage basins, the dividing line between watersheds.

Factors in Watershed Performance - - The individual factors in watershed performance, viewed by themselves, are simple and easily understood. They are degree of slope, type of soil, open or close texture of the surface, and plant cover. The sum of the factors, including the necessity for uses of watershed lands for vital purposes other than gathering water, builds into a complex picture.

The volume of precipitation is a primary factor in the amount of water which will become runoff. A greater amount of water falling from the skies hastens the disintegration of soil material and insures more plant growth.

The earth texture, both in surface soil and underneath, is another factor in how much will flow down a slope and how much will enter into the underground flows.

Movement of Water Through Earth - - There have been approximately 2,000 natural earth samples tested in hydrological laboratories to try to arrive at an indication of how fast water will move through various textures of earth.

The most open soil will allow the water to travel through it approximately 450 million times as rapidly as would the most close-textured material. Gravel with a high proportion of open spaces will let water travel through it at the rate of about 60 feet per day when the slope is as little as 10 feet per mile. The lowest rate for water travel through a close textured soil is at the rate of about one inch in ten years. The vast difference between the rates of flow through the earth materials tested brings into sharp focus how, as we use ground water, we may be drawing from a gravel-channel supply that replenishes the under surface almost as rapidly as it is withdrawn, and how at another point we may be drawing from a reservoir that has taken decades to move from a watershed into that location.

Another factor in the texture of the soil and its readiness to allow water to move through it is its dryness. When a soil is very dry, the spaces between soil particles fill with air. As water enters the ground, air must escape. The rapid absorption of water by gravelly soils is due to the open channels through which air can escape. In a tight-textured soil, there may be such narrow channels between soil particles that the percolating water plugs

the channel from above, pressing down with enough force to prevent the air from rising through it. When a very fast downpour of rain hits a tight clay soil, part of the slicking-over is due to the trapped air below, blocking the infiltration of water. Under favorable conditions, soil can take in from one to two inches of rainfall per hour. Under adverse conditions, a soil may take in as little as one-tenth of an inch per hour.

Action of Ground Cover - - The area in which the three schools of thought, the engineers, the foresters and soil conservationists, and those who believe that a watershed behaves in accordance with its soil infiltration capacity, clash in opinion and theory is the question of what ground cover may do to help or hinder the best use of sky water after it reaches the soil surface.

Ground cover may range from tight, fibrous sod to forests. The four major effects of ground cover on watershed slopes are (1) the diminishing of the pounding of the raindrops on the soil, (2) the binding of the soil by the roots of plants, (3) the building up of organic litter which gradually becomes a porous, open cloak over the basic mineral soil, and (4) the rotting of roots to form a tubular channel for either the infiltration of water or the escape of air from a soil. There are two effects of the litter-cloak spread over the soil: (1) many burrowing, tiny living things, earthworms, beetles, and larvae of insects, construct millions of pipes down into the soil through which water will more readily percolate, and (2) the dead stems and leaves lying on the soil surface provide myriads of tiny obstructions to surface runoff while it is a tiny trickle, holding water back, allowing it to be absorbed if there is absorptive power left in the soil, and preventing the trickles from becoming little gully-gougers.

Action to Secure Best Use of Soil and Water - - We must see what we can do under the conditions of soil, water, and plant-cover now existing, to secure the best use of the soil water-wealth we have in a watershed.

We cannot modify the major phases of the hydrological cycle. We must accept existing slopes, except for some modification by using great earth-moving machines that form terraces. The basic soil under the surface cannot be materially changed. We can manage the upper root-zone of soil to some extent, but not the main body of the soil and its behavior with regard to water that enters it. This being the case, methods of soil cultivation become a major factor in watershed management.

Roughly speaking, we have three types of land culture that produce effects upon the flow of water in a watershed. These types are the forests and brushlands, the grasslands grazing-areas, and the tilled farmlands.

Role of Forests in Retarding Run-off - - Originally there were over 800 million acres of forests in the United States. Only an estimated 494,898,000 acres remain under forest cover, and much of this remainder has been so cut-over, slashed, and burned that it lacks the quality of unused stands. Comparisons between run-off from forest lands and other lands follow. During the 1931-1932 flood in the Yazoo River Basin in Mississippi, 60 per cent of the total rainfall that fell on a certain area of tilled land rain off in the flood-waters, while, in a near-by undisturbed oak forest, only $\frac{1}{2}$ of one per cent of the downpour was recorded as run-off. Near Ithaca, New York, between March 1 and 19, 1936, 88 per cent of a recorded rainfall of 9.7 inches ran off a 14 per cent slope in a frozen potato field, while less than $\frac{1}{2}$ of one per cent of that rainfall ran off

a near-by forested area on a steeper slope. The forest litter had prevented the ground from freezing, forming an insulating blanket and trapping the rain so that it would percolate through the unfrozen ground. At the peak flow of a flood in the Copper River Basin in Tennessee, forest areas were delivering between 30 and 56 second feet for every square mile of the watershed, lands that were partly grazed were delivering 832 to 900 second feet per square mile, and lands that were totally divested of covering delivered from 1263 to 1434 second feet per square mile. The records of 19 maximum storms on Bent Creek in North Carolina show that water poured off abandoned lands that had been in cultivation 18.7 times more rapidly than on adjacent forest land. At Guthrie, Oklahoma, a burned patch of forest area allowed 28 times as much water to run off as an undisturbed area, and, as the water ran, it took 10 times as much soil from the burned area as it did from the undisturbed area. It has been found that the average forest litter of the Appalachian, Ohio-to-Missouri, and the northern hardwood forest areas will absorb water, in the amounts of 3 to $5\frac{1}{4}$, $3\frac{1}{2}$, and 3 to 9 times, respectively, their dry weights.

It has been estimated that there are nearly 1,250,000 insects per acre of forest litter and soils, whose activities keep forest soils open under leaf mats, and that the population of earthworms in forest litter soils, whose excavations form tubes to let water percolate into lower strata, may reach 50,000 to the acre. Very few earthworms are found in a bare-soil area.

Retention of Water by Grasslands - - The picture of the associated elements of a forest community, which contribute to the retention of water, is not greatly different on the grassland areas, which comprise the pastures of the east and the grazing lands of the west. The pasturelands of the east, having more rainfall, can maintain grass cover under fairly heavy use. The vast stretches from the great plains westward cannot carry such a heavy loading of stock. The replenishment of the leafage and young stems of grass is not so rapid, the soil mat does not build back so rapidly, the soil tends to have more mineral content, and too heavy a grazing use rapidly beats cover down to where the basic soil is bared and begins to discharge water. The Missouri Agricultural Experiment Station has reported that the run-off from an area of continuous bluegrass was only 12 per cent of rainfall and the soil carried with the water amounted to 3/10 of a ton per acre, while bare ground, of the same basis type, same slope, and same rain sent nearly 1/3 of the rainfall on its way downhill, carrying away top soil at the rate of 14 tons per acre.

Management of Croplands - - Of the total of 1,903,000,000 acres in the nation, approximately one-third, about 610,000,000 acres, is classed as cropland, of which about 50,000,000 acres have been rendered useless by bad land-practices and another 50,000,000 acres are damaged so badly that they are slipping toward uselessness. This lost cropland is equal to all cropland in Ohio, Illinois, Maryland, and North Carolina. Not only has the crop production been lost, mostly because of the effects of the damaging erosive action of water, but the skinned soil has lost its waterholding capacities and discharges mud under heavy rains, pouring both water and silt into river channels below.

The impact of the plow and the axe on lands that are part of the watersheds has torn the original protective and binding cover, and we now have the problems of managing the changed surface of the land as best we may, both to conserve the soil and bring these lands to the best service in gathering our water supply. Fortunately, good land management is closely allied by nature to a good watershed management.

Instead of plowing under the root and humus mat of the top layer of the soil and placing more erodable soil on the surface, a thorough program of litter farming, consisting of cultivation in such a manner that leaves and stems of crop plants are left in the upper layers, may counteract much of the erosion suffered by the turned-up soil. Litter farming also increases water-receptive power.

A conventional plow will slice along about a foot below the surface. As it does, the shoe of the plow may form a slick layer between the tilled soil and the earth below, much as a trowel sliding along the moist earth might do. There can be a definite barrier thus formed between the open top soil that has been plowed up and the base soil below.

The same slicing action of the plow destroys the tubes between the surface and undersoil, and then the continuous channels that rotted roots and earthworms may have formed will no longer exist. Turning up the bed or stratum of weathered material which underlies the surface soil, breaking up the slick of the plow shoe, plowing plenty of organic matter back into the soil, contour plowing, and terracing not only go far in trapping the raindrops where they fall and letting them enter the ground, but also aid in soil conservation, flood prevention, and watershed stability.

Effect of Land-ownership Pattern - - One of the most troublesome difficulties in securing the integrated use-planning of soil and water lies in the land-ownership pattern. This difficulty is most clearly demonstrated in the small watersheds. Any river basin, however, is made up of small watersheds, and what affects these primary units affects the entire basin. Our land survey pattern has been generally laid out on a straight-line basis. Watersheds have curved, meandering lines. The physical lines of basin management, small to large, are overlaid with this straight-line land-ownership design. Therefore, any sound soil-water conservation plan has to be worked out through cooperation of many owners. Regardless of this handicap, American farmers are now cooperating in soil and water management.

Before the advent of contour plowing, the straight boundaries materially affected the direction of tillage lines. The really super-farmer in the corn belt, for example, used to be the one who would have rows of corn so straight one could look down their lines from one side of the field to the other. When the straight plowed rows were on slopes and heavy rains came, the corn would be totally washed out of the upper ends of these rows and at the lower end would be muddied over by the accumulation of washed soil.

Major Elements of a Soil Conservation Program - - Contour farming, strip farming, terraces that catch and hold back run-off so that it will not wash away soil from sloping fields, and sound forestry practices form major elements of a soil and water management program which will be greatly effective in the conservation and proper use of these vital resources. There is a long stretch still ahead in getting land-owners to cooperate fully as they manage their holdings.

Over-use of Grasslands - - Excessive grazing causes watersheds to deteriorate. Near Boise, Idaho, where good bunch grass formed a sod over the earth, the run-off was 4/10 of one per cent of the total precipitation. That slight run-off of water carried away six pounds of surface soil per acre. When the bunch grass was so heavily grazed that it was beaten out and replaced by an annual called cheat grass, the run-off was 25.5 per cent of the total precipi-

tation, and 2,017 pounds of surface soil per acre were washed away. Taking still another step in range deterioration with the shift from cheat grass to what is known as the needle grass and the lupine types, plants which grow on poor soils, the run-off increased to 47.6 per cent of the precipitation and carried away 4,783 pounds of top soil from each acre. Finally, beating the range further, until even the needle grass-lupine types gave over to annual weeds, the runoff increased to 60.8 per cent of precipitation and carried away topsoil at the rate of 15,280 pounds per acre. These successive deteriorations of the watershed constitute soil-robbing of the first magnitude.

Over-use of grasslands is one direct cause of heavy silting of reservoirs. Since 1929, the silt deposited annually in Lake Mead, the reservoir behind Hoover Dam, has amounted on the average to 100,000 acres of ground, one foot deep, and has caused Lake Mead to lose approximately 2½ million acre feet of water storage space. The silt is not only lost from production of crops and food for grazing animals but it goes on to do damage to water values down stream. It is a damage that may occur anywhere after the skin of the earth has been ripped and starts to bleed.

Top-soil Losses -- Bad practices in the critical zone of conservation just below and just above the soil surface caused 10 million acres in the Northeastern States, in the two decades ending about 1933, to be abandoned as cultivated areas. Undoubtedly the major reason for such abandonment was loss of top soil, the direct result of trying to farm slopes, where soil could have stood up in grass or forest use but not under plow.

The bleeding top-soil from a skinned watershed, even one which is merely in the first stages of losing its root-humus mantle, suffers loss plus loss. The first loss is the loss of the most fertile soil. The action of ripping off soil by water out of control adds to the cutting ability of the water. Sandy soil suspended in water constitutes liquid abrasive. Muddy water cuts gullies faster. The volume of soil in out-of-control water adds to the volume of run-off. It may actually increase the force and damaging power of floods through increased weight and bulk, by 25 per cent or more.

Silt in flood waters is carried in suspension on abrupt slopes by the velocity of the waters. When the velocity is decreased by the arrival of the waters on lower, more level ground, the waters lose their silt-carrying capacity and drop mud over productive land, kill crops, choke channels, and bury roads. They go on to fill reservoirs on major streams or clog river channels that must be dredged to permit navigation. Finally, they end up in harbors where more dredging has to be done to keep them functioning.

The combined effects of soil action and water behavior, indicated in the two preceding paragraphs, cannot be separated so long as water runs downhill. They should convince thoughtful and farsighted people that the maintenance of soil mantles on drainage basins is a matter of great urgency.

Management of Forest Areas ---There remains the question of water loss when forest trees catch rain and turn it back into the atmosphere. Those who oppose watershed forestation make a point of this fact. The U. S. Forest Service has shown that by managed cutting, that is, cutting not only with an eye to timber production and future tree growth but also to increased delivery of water from forested basins, stream flow may be increased materially. With well-planned open spaces, which will fill with young trees as years pass, an increased delivery of 32 per cent in the sky water from spring rains reaching the soil, and

35 per cent more of summer rains, resulted when managed cutting was followed. The timber is harvested, the open spaces to let rains in are cleared for young trees to grow therein, and, as they grow there is managed cutting, opening other spots in the forest to trap rain. There was no damaging erosion where these results were obtained. The water which came from these managed areas constituted a steady, clear flow. The management of water, delivered from a collecting basin and flowing down our streams, must start at the ridge lines of our watersheds if we are to attain the best results in our efforts to conserve and use properly our vital resources of soil and water.

Action to Effect Soil Conservation -- Harvesting of forest crops from high basins will be continued. These crops may be so harvested, however, that they will improve the watersheds in those basins. Land which formerly was sod and forest cover will continue to be tilled. This land may still serve efficiently as part of the watershed machinery. The counsel of the Soil Conservation Service and efforts of the Soil Conservation Districts have caused a tremendous advance in this particular part of the whole watershed problem within the past few years.

Good management of land includes the management of soil in a manner which maintain or improve watershed values. The contour planting of row crops aids each little ditch to delay run-off and hold soil in place. The building of terraces has the same value. The necessity of maintaining organic matter in the upper soil, so that it will continue as a good growing medium, also keeps soil porous and open for the purpose of trapping rain where it falls on the cultivated fields.

In planning a farm unit, it is usually desirable to put steeper slopes in permanent pasture. Cultivation of these slopes is detrimental to watershed values. Study may indicate that a farm pond can return more value than the same acreage drained and plowed. A pond of a few acres, well managed, may produce 300 to 600 food fish per acre per year. Income from this production may equal what could be derived from crops grown on the drained bottom of that pond. If this income is added to the values of maintaining ground water levels underneath adjacent areas of stock-watering facilities or supply of water for irrigation purpose when needed, and of recreational facilities for the farmer and his family, the total results in an amount which favors retention of the pond and establishes another slow-feeder for downstream flow.

There should be less draining of swampy areas in the higher reaches of catchment basins. Some drainage projects may be profitable if they are carried through. The value, however, of a swamp or bog as a water-flow regulator and a stabilizer of water in ground reservoirs in adjacent lands, should be a primary consideration. Many drainage schemes have turned out as failures in adding cultivable land to production.

Water should be retarded in its travels from where it falls. Particularly, it should be trapped as long as possible in higher gathering basins. If it is hurried away, the opportunities for use are lessened. The more slowly it may travel, the more uses may be made of it.

Efforts to adjust forest uses equitably should be supported. Any move to increase soil mat and more grass cover, with its fibrous roots and better forage values, should be encouraged. Pasture practices should include good grazing and ground-protection conditions.

The highest possible usability of water throughout the line of transit from the point of precipitation to its return to the sea should be maintained. Re-use and further re-use are imperative. Those who damage water beyond re-use are detrimental to community life.

Water Control - - The control of water for more beneficial use by man - for limitation of its destructiveness dates back to ancient times. The need for control measures, however, has never been so urgent as at present.

Our constantly increasing demand for more and better crops, and more land for expansion of towns and cities, means that land must be used more intensively than ever before. In turn, soil erosion, sedimentation, and flooding must be limited to permit increased land use. The key to all of these practices is the control of water from the time it falls upon the ground until it returns to the ocean.

Water control may be divided between practices which tend to reduce the rate at which water runs off the land and practices which regulate the water after it reaches the main streams. The former practices are essentially a part of watershed management and are closely related to sound practices in soil use. The latter practices include flood control, navigation, water supply, hydroelectric, and other developments in which water is regulated in streams and lakes.

Problems of Watershed Management - - No blanket answers can be given to problems of watershed management. No two catchment basins are exactly alike. Even in a primary watershed of a tiny creek, one acre may be in cultivation while across a fence another is devoted to the growing of trees or is covered with grass. Each ground surface, and all of the soil underlying that surface, affects the way water will begin its travels downhill. Slopes vary from almost level to the vertical. The amount of precipitation and the climate factors determine the vegetation which can grow on these slopes, and plant types affect run-off. The seasonal conditions may enter as another factor in how water runs out of the little primary watersheds. Frozen ground cannot absorb water. These factors and many others combine to affect the way water is delivered out of the samll basins where streams begin.

Contradictions as to what is best in the management of watersheds are found among experts. There are three general schools of thought among authorities on watershed management.

An engineering viewpoint argues that, since there will be about so much average precipitation on a watershed, a proportion of it will flow down the stream regardless of conditions at the soil surface and, if dams are installed to catch this flow, it will be put to use. The extreme in mechanical organization of a watershed, based on this viewpoint, would be a paved basin with no plant growth to rob water or delay its downward flow, all water shooting down quickly to a reservoir, where it could serve various purposes through the mechanics of flumes, turbines, ditches, canals, and other engineering installations.

Many foresters, soil experts, and conservationists regard the ideal watershed as one clothed with plant growth, the roots of which bind the soil against the erosive action of water, while the decayed vegetable litter on the ground traps the raindrops and lets them filter into the earth below to come out farther down slope in clear, constantly-flowing springs. If run-off does occur on slopes so clothed, it is delayed in racing downhill, assuring only moderate rise in rivers below, even with flood-level rain.

The third group argue that leaves mat above the ground surface, roofing it and causing water to run off more quickly. They indicate that a stand of timber will intercept showers or snows, with evaporation of intercepted precipitation before it can reach the soil surface. They argue that evaporation by plant growth may far overbalance any value which the plant cover, particularly forests, may have in binding soil with roots and carpeting it with litter. Their thesis is that the main consideration in how a watershed behaves is based on the soil infiltration capacity.

Development and Control of Water in Wisconsin - - In a brief outline, Mr. G. C. Neff, President of the Wisconsin Power & Light Company, gave the high points of a 50 year-old program for development and control of water resources by private enterprise in the State of Wisconsin. This program started in 1907 when the State Legislature made possible the functioning of a Wisconsin Valley Improvement Company. The privately-financed company has authority to build reservoirs, regulate stream flows, and charge tolls to those benefiting from such regulation. Under the "Wisconsin Plan", river-flow is regulated, land is reforested, and recreation facilities are developed, all with private financing. There is no government subsidy.

The State supervises what the company does with rivers; the Public Service Commission supervises what it charges for what it does. Tolls are meant to be well within the value of service to owners of dams on the rivers; yet they are sufficient to pay all costs of the company. Costs include a 6% return on investment in addition to local, state, and federal taxes in full.

The Wisconsin Valley Improvement Company has built and now operates 21 storage reservoirs, regulating a river and running 26 privately-owned hydroelectric plants. Similar situations exist on other Wisconsin streams. Flood dangers have been minimized on a large number of rivers, and the flood-control costs are being reimbursed by toll-payments of utilities and industries for regulated flow.

Trees for Tommorrow, Inc., a non-profit organization backed by five private utility companies and 12 paper mills, has distributed six million free trees to Wisconsin farmers and planted another three millions itself. It also prepares land-management plans and sponsors conservation education.

The Wisconsin Plan facilitates coordination of construction and operation of plants by private utilities, under surveillance of the State Public Service Commission. Electricity reaches 97.9% of farms in Wisconsin, where 12.5% more power than the national average for residential users is consumed at a 9% lower-than-average cost. This power is mostly stream power in a state with no coal, oil, or natural gas of its own.

Mr. Neff asserted that the Wisconsin Plan has succeeded because State laws and business climate have been right. The private enterprise scheme has flourished under fair rules and adequate local regulation. He proposed that the plan, if used generally throughout the United States, would cut greatly the expenditures by the Federal Government while increasing materially tax income at all government levels.

Need for Topographic Mapping - - Successful watershed management must have as its basic background sufficient reliable data for a comprehensive study of all factors pertaining to water resources. One of the many sources of basic

data is topographic mapping. These maps portray the topography and other features of the earth's surface. Topographic maps are the essential foundation for geologic, hydrologic, and soil maps.

Although topographic mapping has been carried on in a limited way for almost 100 years, only about 25 per cent of the area of the United States and Alaska is adequately covered with topographic maps, an additional 25 per cent being very poorly mapped. One-half of the mapped area is represented by small-scale, reconnaissance maps, most of them old and inadequate for modern needs and conditions. Only 25 per cent of the total area, mainly in the older settled sections of the country, have maps suitable for modern needs. Mapping has been largely concentrated in areas of local demand. Our rapid economic development has made it now an urgent nation-wide consideration.

Demands from many sources establish the needs for an accelerated mapping program. Any mapping that may be contemplated will be of far more value to the Nation if done immediately, so that whatever development activity lies ahead may have the benefits provided by accurate terrain information.

While current needs are rapidly expanding, the rate of the present mapping program will require 50 years to cover the remainder of the country. The shortest practical time for the completion of this program would probably be near 20 years. Such an accelerated project will require a great increase in personnel and the accumlation of much new equipment. The success of such a program would require assurance of its continuance to completion to permit planning and logical scheduling of the work.

An example of how far the United States is behind other nations in topographic mapping is shown by our rank of 15th among 16 other nations, with five of them being 100-per-cent mapped. North Carolina ranks far down the line when compared with the majority of the other states.

All factors affecting the absorption, circulation, conveyance, and storage of water, and its destructive forces, can be portrayed on hydrologic maps with topographic and geologic maps as a base. Such maps are prerequisits for intelligent planning and development of water-resources projects and their effective management.

Hydrologic maps constitute a new type of mapping, the features of which are only slowly being clarified. The very magnitude of the water-resources projects now underway make it necessary that maps reveal the hydrologic features as completely as geologic maps now reveal the mineral characteristics.

From the time water is precipitated from the atmosphere, its natural course and behavoir, and the projects for its management and control, are basically topographic and geologic except as modified by vegetative cover. The present magnitude and the rapidly accelerating rate of construction of projects for water-resources development multiply the needs for a complete and reliable foundation of topographic, hydrologic, and geologic maps. This sound foundation is required for the effective design and appropriate location of structures for the control of surface and subsurface streams and reservoirs; the design and construction of facilities for drainage and flood control; and the use of water for irrigation, domestic, industrial, and transportation purposes.

Topographic maps are an important part of the fundamental data which must be obtained in the efficient execution of water-development programs. They portray, by means of accepted symbols and nomenclature, the natural and man-made features which comprise the land surface.

In view of the fact that less than 25 per cent of the United States is adequately mapped for water development purposes, the serious need for long-range planning and positive action in the production of topographic maps becomes apparent.

Prior to field investigations, an office study of drainage basin characteristics can be made with the utilization of topographic maps. Those characteristics are slope, probable run-off, length and density of drainage channels, and the average elevations over the entire area. The determined drainage characteristics lead directly to a knowledge of the factors affecting floods and flood control. Since they are related to elevation, both precipitation and snow storage can be partially forecast from data provided by the map. Sites for flood discharge can be chosen. With the elevation datum points shown, accurate determinations of flood crest stages and flood crest profiles can be made.

There is great need for a complete hydrologic mapping of our drainage basins that will clearly depict all of the factors affecting the management of our water resources. This would involve an extension of the maps showing surface water in rivers, lakes, and other water bodies, to include the characteristics of head waters affecting water retention, run-off, and subsurface channels and conditions influencing water movements, storage utilization, and all features related to erosion and destructive floods.

Watershed Protection and Prevention Act - - Public Law 566, 83rd Congress, approved August 4, 1954, contains a declaration of Federal policy that "erosion, floodwater, and sediment damages in the watersheds of the rivers and streams of the United States, causing loss of life and damage to property, constitute a menance to the national welfare; and that it is the sense of Congress that the Federal Government should cooperate with States and their political subdivisions, soil or water conservation districts, flood prevention or control districts, and other local public agencies for the purpose of preventing such damages and of furthering the conservation, development, utilization, and disposal of water and thereby of preserving and protecting the Nation's land and water resources."

The act authorizes the Secretary of Agriculture, in order to assist local organizations in preparing and carrying out plans for works of improvement, upon application of local organizations, to take the following actions:

(1) Conduct such investigations and surveys as may be necessary to prepare plans for works of improvement;

(2) Make such studies as may be necessary for determing the physical and economic soundness of plans for works of improvement, including a determination as to whether benefits exceed costs;

(3) Cooperate and enter into agreements with, furnish financial and other assistance to, local organizations; and

(4) Obtain the cooperation and assistance of other Federal agencies in preparing and carrying out plans for works of improvement.

The act provides that the following actions shall be taken by local organizations as conditions for providing Federal assistance for the installations for works of improvement:

(1) Acquire without cost to the Federal Government such land, easements, or rights-of-way as will be needed in connection with works of improvement installed with Federal assistance;

(2) Assume such proportionate share of the cost of installing any works of improvement involving Federal assistance as may be determined by the Secretary of Agriculture to be equitable in consideration of anticipated benefits from such improvements;

(3) Make arrangements satisfactory to the Secretary of Agriculture for defraying costs of operating and maintaining such works of improvement, in accordance with regulations presented by the Secretary;

(4) Acquire, or provide assurance that landowners have acquired, such water rights, pursuant to State law, as may be needed in the installation and operation of the work of improvement; and

(5) Obtain agreements to carry out recommended soil conservation measures and proper farm plans from owners of not less than 50 per cent of the lands situated in the drainage area above each retention reservoir to be installed with Federal assistance.

The act authorizes the Secretary of Agriculture, at such time as he and the interested local organization have agreed on a plan for works of improvement and he has determined that the benefits exceed the costs and the local organization has taken the actions set forth in the preceding paragraph, to assist such local organization in developing specifications and in preparing contracts for construction and to participate in the installation of such works in accordance with the plan, under the following conditions:

(1) Any works of improvement shall not be in a watershed exceeding 250,000 acres and shall not include any single structure which provides more than 5,000 acre-feet of total capacity.

(2) No appropriation shall be made for any plan for works of improvement, which provides more than 2,500 acre-feet, unless such plan has been approved by resolutions adopted by the Committee on Agriculture and Forestry of the Senate and the Committee on Agriculture of the House of Representatives, respectively.

(3) At least 45 days (counting only days occurring during any regular or special session of the Congress) before such installation involving Federal assistance is commenced, the Secretary of Agriculture shall transmit a copy of the plan and the justification therefor to the Congress through the President.

(4) Any such plan which includes Federal assistance for flood water detention structures shall be submitted to the Secretary of the Army for his views and recommendations (presumably based on the views and recommendations of the Chief of Engineers, Department of the Army) at least 60 days prior to transmission of the plans to the Congress through the President.

(5) Prior to any Federal participation in the works of improvement, the President shall issue such rules and regulations as he deems necessary to carry out the purposes of the act, and to assure the coordination of the work authorized under the Act and related work of other agencies, including the Department of the Army.

National Watershed Congress -- The first annual National Watershed Congress, sponsored by the American Nature Association, American Watershed Council, Forest Conservation Society of America, Friends of the Land, Izaak Walton League of America, National Farmers Union, National Grange, National Wildlife Federation, Soil Conservation Society of America, and sixteen other national organizations, was held in Washington, D. C. on December 6 and 7, 1954. About

350 persons attended sessions of the Congress, including representatives of forty States and the Province of Québec. The views and recommendations of the ten committees which presented reports at the Congress are set forth below in condensed form.

COMMITTEE I: Elements of a Sound National Land and Water Policy

A sound national policy for the conservation, development, and sustained use of our land, water, and related natural resources should:

(1) Insure adequate renewable natural resources for the needs of an increasing population and an expanding economy;

(2) Recognize that these resources are interdependent and bound together in the system of nature and that programs for their conservation, development, and constructive use should deal with them in their proper combination and not separately;

(3) Provide for their conservation and orderly development on a planned and continuing year by year basis instead of by haphazard or emergency action;

(4) Endeavor to develop their full potential usefulness, with the broadest possible benefits to the public; and

(5) Involve Federal, State and local cooperation and coordination of effort, with an equitable sharing of costs and the maximum practicable local initiative and responsibility.

Practicable reasons and a favorite public attitude make the primary or, as better known, the small watershed the most feasible approach to such a policy. Beginning with conservation practices on the land that restrain wasteful water run-off and soil loss, multi-purpose programs can be planned to yield such benefits as erosion control, reforestation, stream stabilization, water storage, flood reduction, recharging of underground water levels, protection of farm, municipal, and industrial water supplies, and increased recreational opportunities. The benefits of more regular stream flow and water delivery, lessened flood dangers, and siltation-prevention will extend to downstream communities.

The primary or small watershed is also the most effective approach from the stand-point of people as well as nature. Because it is close to them, both rural and urban people living in the small watershed can see at first hand the mutual benefits they will share in a watershed development program. This unity of interest encourages cooperative action and a willingness to assume local responsibility. The Soil Conservation Districts, watershed associations, conservancy districts, and business, farm, sportsmens', and other groups common to the American community provide a readily availabe leadership to initiate, plan, and organize such programs. With the necessary technical assistance furnished by Federal and State agencies and an equitable sharing of costs, the process of Federal, State and local cooperation becomes a working reality.

To forward such a national land and water policy, these steps should be considered:

(1) Increased Federal, State, and private research to determine what physical measures are most effectual in watershed development;

(2) Action by the States, not now so equipped, to set up competent State and local agencies to assure full coordination at the State and local levels, and

(3) Adequate legislation by the States, in advance of the increasing demands on the water supply, to determine the respective rights of water-users and settle "whose water is it?"

Programs on the sub-watersheds of a larger stream basin can be coordinated in plans for basin-wide improvement and geared in with downstream projects for flood control, power development, irrigation, and water-reserve storage. The States, acting through their responsible resources agencies, can integrate watershed development plans in State-wide programs. With the necessary upstream work under way, the States can synchronize their watershed programs with plans for for major river basin improvement. By such progressive stages, a program of nation-wide scope would be brought within range of realization.

COMMITTEE II: Review of Existing and needed Federal Legislation

The bulk of Public Law 566 should be put through a reasonable but limited testing time to give the administrators an opportunity to show what benefits can accrue from the law in its present form. The limited and restricted language in Section 4, providing that no factors other than flood prevention, in an impounding structure, shall be considered in determining whether Federal assistance can be granted, should be revised and improved at the earliest opportunity in order to permit greater and more varied benefits, to be accorded the people of America through this new small watershed program. The enlargement and broadening of the benefits for impoundment structures should entail full and equitable participation in the costs thereof by the residents of the area who are to be benefited by the construction.

The Committee believes that Public Law 566 provides an affirmative, constructive approach to many of the rural and urban water problems of the Nation. It is a mechanism that can and should be employed as quickly as possible in many small watersheds for community safety and well-being. This positive approach differs sharply from the negative, defensive one that is inherent in the flood control programs with which our citizens and lawmakers have for so long been preoccupied.

It must be remembered that nearly every State in the eastern half of the nation is now considering fundamental water legislation. We are soon to see a report from the new Hoover Commission, which will contain a section relating to water and watersheds. The other major group now grappling with problems of national water policy is the Cabinet-level committee named earlier this year.

This committee (Committee II) suggests a close review of the nation-wide emphasis of flood control as it relates to damage done by excessive rainfall, while within a very short time drought may follow. Emphasis should be placed to stress the importance of balancing supplies of water with needs for water at a given time and place. Isn't it time we recognize that these extremes can be dealt with far more effectively when each landowner participates in an overall program for community benefit?

COMMITTEE III: A Basic Approach to State Legislation for Watershed Management

The Committee has attempted to outline the more basic legislative elements necessary to watershed work in any state. It must be left to each state to adapt this fundamental structure to its own needs, desires, and capabilities.

The first requirement is to take a long, careful look at existing legislation with a view to seeing how it might be used intact or amended or replaced.

Present laws, authorizing such entities as soil conservation and conservancy districts or establishing the powers of county commissioners or supervisors, might well provide at least a part of the necessary legislation.

It is important to make every effort to coordinate supplemental legislation with existing laws. Such effort is particularly true in the case of soil conservation districts. While authority of these districts vary from state to state, they can supply much of the needed responsibility in rural areas. It might be possible and desirable to expand the powers of these districts to cope more efficiently with watershed problems.

A minimum of new legislation might make it possible to use existing laws more effectively in watershed development. An example of this is the county compact law. In most states, county commissioners or supervisors have practically all of the powers needed to carry out watershed work in their own counties. If counties enter into a compact agreement, these powers can be extended across county lines and exercised throughout a watershed.

New agencies such as watershed districts are likely to be needed. Watersheds encompass both rural and urban lands. While soil conservation districts might well provide all of the necessary authority in the rural areas, they are not equipped to handle urban matters. In drafting new legislation or establishing new agencies for watershed work, the following provisions should be considered:

(1) Empowering the agency to tax, condemn, manage appropriated funds, and enter into contracts;

(2) Organization of districts by petition or general election, and requirements for organization sufficiently elastic to be practical in all parts of the State;

(3) Permitting district boundaries to be coextensive with watersheds;

(4) District boards representative of both rural and urban areas and fairly representative of all major potential beneficiaries, and use of local discretion to determine percentage of members from each group of beneficiaries;

(5) Authority to apply taxes in proportion to benefits received by individual tax payers;

(6) Authorizing agency to plan and develop all potential uses of water in its area;

(7) Provision for inclusion of recreational facilities;

(8) Provision for pollution abatement and related public health problems;

(9) Maximum local cooperation; and

(10) Making possible and encouraging participation in the National Watershed Program.

Above all, it should be borne in mind than no watershed program will be successful without the cooperation of the entire community. Any legislative machinery should be aimed at making that cooperation possible.

COMMITTEE IV: Development of Adequate State Agencies

A State Natural Resources Agency is necessary. It should have authority to control water resources, soil resources, and fish and wildlife matters. Such an agency will be required for participation in the provisions of Public Law 566, in connection with which the State will not want to continue with several agencies. The State agency sponsoring watershed protection works should be concerned with conservation measures.

In order to develop an adequate State agency, the people must tell legislators what they want. California is consolidating all water laws into one law. Everybody's business is nobody's business. The people of California will ask the State Legislature for a contribution for work under Public Law 566, which cannot be performed efficiently without one agency.

The Ohio State Department of Natural Resources appears to be a model agency. It is engaged in an inventory of water and how it behaves. It includes the following divisions: Land and Soil, Water, Forestry, Parks, Wildlife, Geological Survey, and Shore Erosion.

COMMITTEE V: Federal Appropriations

There should be the following objectives for Federal spending, which are interrelated and are best planned together in watershed units:

(1) To halt the falling water table, and to re-establish underground water reserves essential to agricultural and urban water supplies;

(2) To prevent waste of water so that it can be utilized not only in arid regions but also for supplementary irrigation in the rain belt for land improvement, and for industrial and recreational use, by retaining water at all levels of the watershed in marshes, lakes, ponds, and reservoirs, and by absorption of rainfall in the soil; and

(3) To prevent damage by water, that is, soil erosion, silting, and floods.

Land management is essential to retain water in the soil and to prevent erosion. Flood damage can be further reduced by engineering methods, such as increasing the capacity of rivers to carry flood flows, construction of flood walls or levees, and storage behind dams.

The cost of accomplishing the above objectives should be borne by local, State, and Federal governments, according to the benefits received and their ability to pay.

A Federal appropriation, adequate to start 200 watershed projects each year and the funds to be continuous, is recommended. If work is started in 200 watersheds each year and pilot watershed experience is used, the Federal appropriation for this purpose for the first year would be $20,000,000, since pilot watershed experience indicates that the work in an average watershed, except for maintenance, can be completed in about five years. The annual continuing appropriation at the end of five years would be $100,000,000.

It is recommended that the legislative and executive branches of the Federal government consider the development of a priority rating system, whereby the urgency of work in watersheds can be impartially evaluated.

COMMITTEE VI: Federal, State and Local Cost - Sharing in Watershed Development and Protection

The beneficial use of water has become a composite problem, for the solution of which individuals and the local, State, and Federal governments may wisely expend funds upon carefully planned projects, provided that they stand the test of financially sound investments after all benefits, costs, and damages have been fully weighed.

Local initiative should prevail in the planning and the execution of works of improvement for small watershed protection. The principal role of the Federal government is in comprehensive planning, development of standards, and the right to review plans prepared by local agencies or the States.

The principal beneficiary of the soil and moisture control practices on the land will be the landowner, and he should assume his equitable share of the cost. Some of the capital costs may be shared among the landowners through soil conservation or conservancy districts or other subdivisions duly authorized by the State legislatures. The landownders on the tributary streams below generally will benefit from reduced silt, more regualr stream flow, and a more uniform water table, although there is some evidence that in semi-arid watershed conservation may reduce even the beneficial run-off. The local and State governments and the Federal government will benefit through increased tax valuations and from indirect benefits. In return for such benefits, part of government's share of the costs might take the form of furnishing technical aid and assistance and in research work.

The check dams and small reservoirs for flood prevention on the tributary streams, however, provide direct benefits to the property owners immediately below them by preventing or reducing the ordinary annual floods. Such benefits will increase down-stream away from the dams and will be practically negligible on the main rivers miles away from the headwaters. Headwater dams will have little or no effect in reducing the periodic catastrophe floods and may even add to them.

It will be practically impossible to allocate the costs of these works directly to individual property owners, and the costs will have to be shared by the conservancy districts, the local and State governments, and the Federal government. The combined contributions from the other sources toward initial costs should exceed the Federal contribution.

The Committee recommends the following principles for Federal, State, and local cost-sharing in watershed protection and development:

(1) Congress should establish a National Land and Water Policy with uniform standards. In order to coordinate the watershed program with the water resources programs of the Corps of Engineers, the Bureau of Reclamation, and other water resources programs, there should be created a non-partisan Board of Coordination and Review, appointed by the President with the approval of the Congress. Its duties should be to make impartial analyses and appraisals of proposed Federal water and associated land resources projects. The Board's review and reports thereon should be prerequisite to the authorization of projects by Congress and the appropriation of funds therefor.

(2) All Federal aid for land and water resources development, improvement, and conservation should be proposed in a single unified budget with recommendations as to the amounts to be allocated to the various Federal agencies.

(3) All resource development, improvement, and conservation projects should require some degree of non-Federal cost-sharing. The division of costs between the Federal, State, and local governments and the property owners should be based, as far as possible, upon the incident of benefits.

(4) The analysis of benefits and the allocation of costs of the two main types of watershed programs--soil and moisture control practices on the land, and flood prevention structures on the streams--should be figured equitably and realistically.

(5) The granting of Federal aid to States or regional areas should be based on the same standards applied uniformly in all sections of the country.

(6) Priority of aid to individual watershed projects within such political or geographical divisions should be determined by the highest financial participation offered by the States and local interests.

(7) The ownership and maintenance of all projects should be assumed by the States, or local subdivisions, or entities set up by the State government.

(8) The States should have the initiative in determining local priority, while the Federal government should develop standards to be met for final approval.

(9) The organizations participating in this National Watershed Congress should promote the development of adequate State legislation and State appropriations to provide equitable assistance to local organizations consistent with the foregoing principles.

COMMITTEE VII: Principles of Federal Inter-Agency Coordination

Conflicting Federal interests, duplications, and overlappings can best be solved by whole-hearted agreement on the Washington level. This agreement must be preceded or supplemented by:

(1) Placing greater emphasis on the role played by soil conservation districts and other local agencies, public and private;

(2) Revamping of existing State and local laws as needed; and

(3) Congressional clarification of policies when the necessity arises, with Presidential or Congressional intervention if the aforementioned top-level coordination in Washington is not achieved within a reasonable time.

Public agencies concerned with watershed development should be properly staffed and financed so as to secure the maximum effort on the land.

Unless thorough cooperation has been achieved among local watershed interests and resource units, Federal inter-agency coordination will be ineffective. Such local coordination would assure a general public understanding and thus secure continuing adherence to the principles of watershed management.

The situation would seem to call for aggressive action to resolve all Federal inter-agency conflicts at the Washington level.

COMMITTEE VIII: Local Administrative Techniques

There can be no progress in any resources effort unless administrative techniques are clear cut and effective. These techniques are usually dependent upon local leadership, the needs of the people, and the manner in which policies governing their use at all levels of government are understood, defined, and coordinated.

The present watershed thinking generally embraces only the agricultural aspects, such as the prevention of floods and sediment damage, drainage, irrigation, water impoundment, land use, and other conservation measures depending upon local problems and interests. Administrators of many watershed projects are being presented with proposals to expand hunting and fishing facilities and other forms of outdoor recreation, water for urban and industrial needs, pollution abatement, and a host of others. These are real and valid interests and cannot be passed over lightly, especially in view of our reliance on the

watershed as a natural area where all of the renewable resources and their wise use are compatible. There are those who argue for the total-or multiple-use concept. Others take the position that the small watershed program should limit its activities only to the agricultural problems and needs. Local administrators need to know the answers to these questions.

Even though there is no meeting of the minds as to what is generally embodied in a small watershed, administrators of local projects have learned to recognize three types of natural drainage areas, as follows:

(1) Agricultural watersheds in open country or in coastal areas where resource problems concern chiefly the rural interests. The emphasis in these areas must stress water use and management. Flood control is a secondary interest.

(2) Rural-urban watershed areas in which flood and sediment damage and other resource problems concern both the agricultural, urban, industrial, and recreation interests.

(3) Watershed areas much larger in scope than those classified as "upstream". These areas would represent a combination of smaller watershed units, including agricultural, urban, industrial, and recreation interests within a principal drainage basin. Such basin is the area where complete emphasis can be given by all segments of society in the total development of the renewable natural resources, including the economic, social, and cultural aspects. Such an undertaking would obviously involve both public and private interests.

The fact that these or comparable watershed areas are not generally recognized by those responsible for government participation makes local administration exceedingly difficult. There is a great need for a clear-cut policy in this and all other related resource fields at the State and national level. If resource programs are to be administered on a partnership basis, there must be agreement on purpose and objective as well as administration. Without these considerations, the entire program is destined to failure.

In another field, the administration of watershed projects is often hampered by conflict in agency perogatives, both State and Federal, resulting in road blocks not conducive to progress nor the efficient expenditure of public funds. There must be complete harmony in purpose and desire between all groups, public and private. This harmony is the least that the public can expect.

The method of financing watershed projects is another problem of major concern. Even though greater emphasis is being placed on the principle of partnership, federal, state, and local, the fact remains that there is no formula by which local administrators can be guided. In many instances township, city, county, and state units of government have set aside public monies for watershed improvement purposes. This action, however, applies only where tax laws and other legal authorizations are in keeping with local statutes. There are instances where existing irrigation, drainage, and flood control districts are in a strong position to cooperate with watershed programs by making monies derived from tax sources available for local projects. Local administrators generally feel that, as the movement expands, the problem of financing must be put on a sound basis. The solution will require new laws and will vary with every state.

A very careful analysis of local administrative techniques has been prepared for presentation to the National Watershed Congress. It comes from more than 100 leaders of the movement representing 26 states and covers the following considerations:

1. Individual and Community Interest--It is extremely important that the genuine interest, enthusiasm, and willingness of the people to participate in, and assume their rightful place for, the development and completion of a successful watershed program be considered a cardinal principle. This is basically a people's program and must be so considered at all times.

2. Education and Promotion--It is extremely important that the people representing all segments of society thoroughly understand the problems and solutions contemplated in the development. This understanding can be accomplished through the creation of voluntary watershed associations without legal status. These associations would represent the various community interest, both rural and urban, and be responsible for coordinating and developing local resources.

3. Sponsorship--The character of sponsorship must be legal, common to the community, and representative of the problem and interests of the people. The leadership must be competent, strong, aggressive, and alert to changing conditions and needs. Soil conservation districts should be recognized as the primary and dominant body in all small upstream watershed areas considered as being entirely agricultural or rural-urban in character. Consideration should be given to the formation of legal watershed or conservancy districts, as authorized by State laws, in watersheds where corrective problems and techniques covering all aspects of the total resource-needs go far beyond normal small watershed procedures. It is important that soil conservation districts supervisors be at all times closely allied with the formation and operation of such districts. The responsibility of dealing with upstream land and water problems in watershed districts should remain under the direction of the local soil conservation district.

4. Program Planning and Development--This is an extremely important matter and involves the many interests representative of the watershed, and also the physical, social, and economic problems confronting the people. Ordinarily, this is a responsibility of the local sponsor. Every effort should be made to recognize the many interests of the area, including agencies of government concerned with resource and financial problems, and to fix responsibility for the execution of such development programs.

5. Cooperative Action--Such action is the key to successful accomplishment of the job to be done. Cooperative efforts of individuals, local organizations, industrial groups, and local, state, and federal agencies are necessary to carry out methods of finance and the action phases of the watershed development project.

6. Financing and Maintenance--Funds required for administration, purchase of rights-of-way, maintenance, and other items should be shared by local units of government. In some cases, provision of funds might be considered a responsibility of the State, depending upon tax laws and other limitations.

COMMITTEE IX: Public Understanding

It is necessary to sell acceptance of desire for, and participation in, watershed development and protection projects. A National Publicity and Education Committee is needed. The Committee should publish and distribute a handbook guide.

Watershed development and protection projects may be sold through the following media: newspapers, radio and television, field tours and demonstrations,

slide and film libraries which move around the circuits, speakers, magazines and textbooks, sports and farm journals, brochures, post cards, billboards, and posters.

COMMITTEE NO. X: Organization of Watershed Associations

Watershed problems pertain to soil and water and the things they support, such as crops, forest, and wildlife, and to man's use of them, such as erosion, pollution, floods, droughts, water supply, recreation, and transportation. There is urgent need for a watershed organization if these problems are not speedily being solved by existing agencies; if there is conflict or lack of cooperation between existing agencies; if suitable agencies, competent to handle these problems, do not exist; if there is a lack of mutual understanding and cooperation between the different interests in the watershed; or if there is general lack of knowledge of these problems or lethargy concerning them.

People of a watershed become interested in forming an organization once they realize the seriousness of the problem, the effect of these problems on their own health, welfare, and economy, and the effectiveness of their own organization in solving these problems.

Problems should be ascertained, studied, and rated. Easily-answered questionnaires may help. A few leaders in the community should first be consulted and sold on the idea--people who are civic-minded and philanthropic, who are accepted by the community and whose integrity, sincerity, and motives are unquestioned. These leaders in turn can interest their friends and acquaintances so that a nucleus of interested and informed people results. With their approval and help, the problems can be publicized by meetings, discussion, illustrated talks, newspapers, radio and television programs, and other means. The benefits of rapid solution of the problems should be outlined, and the means by which their organization could accomplish such solution should be demonstrated. Pamphlets and brochures of watershed organizations already established will help by showing accomplishments and progress of others.

Initial financial support can be secured by voluntary contributions. Substantial contributions in the beginning from a relatively few very interested persons permit a greater portion of such funds to be used for constructive publicity and for action programs. Once the organization is well known, particularly after some accomplishments can be shown, financial support may be obtained through membership dues, contributions, etc. Substantial support may may be secured from private organizations, such as chambers of commerce, civic clubs, sportsmens' clubs, etc., and from political units such as municipalities, townships, counties, and states. Depending upon the scope of activity and financial responsibility involved, it may be desirable to secure funds through power of taxation. Adequate financing and type of organization should be carefully studied in order to qualify for Federal assistance under Public Law 566.

The most desirable form of watershed organization appears to be the one which will be most effective in the area involved. It may range from a local, voluntary organization in thickly-populated areas to an official State body created by legislative action in sparsely-settled areas. General consensus is that control should remain with local people and that the organization should be incorporated with the usual officers and committees. Where watersheds extend into two or more states, interstate compacts are recommended.

Since much of the work of most watershed organizations is of a research or educational nature, they may well quality for a tax-exempt status.

Watershed organizations by-laws should include:

(a) Name, address, type, and purpose;
(b) Qualifications for, and types of members, dues, etc.;
(c) List of officers, terms of office, methods of election, and removal and duties;
(d) Schedule of meetings, method of calling, notification, quorum, etc.;
(e) Provisions for committees and method of their appointment;
(f) Provisions for amendments; and
(g) Rules governing elections.

The objectives of a watershed organization are to solve the problems indicated in the first paragraph of this committee's presentation and include the following:

(1) To restore, conserve, and improve all natural resources of the watershed for the greatest benefits of all interests therein;

(2) To improve the social, cultural, spiritual, and economic conditions of the people of the watershed;

(3) To make the watershed a better place in which to live, work, and play;

(4) To promote the restoration and conservation of the natural resources of the watershed by scientific research and by means of educational programs and projects;

(5) To provide a common meeting ground where peoples of different minds, of different interests, and of different experience can meet, discuss, plan, and unite to take beneficial community action; and

(6) To help people of a watershed to recognize their problems, interest them in solving their problems, establish contacts with agencies that can give them aid, promote coordination and cooperation, and accelerate a constructive program that will benefit all interests in the watershed.

The type of action programs that a watershed organization should undertake should be determined by conditions existing in that watershed. A careful study should be made, in collaboration with other agencies, of the watershed and of the current problems. If their services are not being utilized, the action program could be one of advertising these services and encouraging people to use them. If the watershed organization is over-worked, action should be taken to augment its staff or facilities. If a needed service is not in existence, action should be taken to create or secure it.

A thorough survey of the soil, the forest, or the waters, or of all of them may be needed. The action programs should consist of securing the interest and help of appropriate agencies and coordinating them in making such a survey. Facts are necessary as a basis for planning and action.

Action programs of a watershed organization should not duplicate or compete with those of other agencies but should complement or accelerate them. Watershed organizations can be of inestimable help in forming soil conservation districts, where needed, and in promoting and accelerating the work of existing districts. The watershed organization can most effectively secure the help of local, state, and federal agencies on local problems.

A watershed organization can very effectively cooperate with schools and colleges by actions as follows:

(1) Organize conservation workshops in colleges where teachers can be trained for teaching natural resources and their conservation in the schools of the watershed. Many parents otherwise indifferent can be reached through their children.

(2) Conduct conservation tours for teachers and their classes.

(3) Prepare and present motion pictures or illustrated talks, preferably in color and on local watershed problems, projects, and progress, to classes, groups of teachers, and school assemblies.

(4) Assist interested and promising students in preparing and presenting pictures and talks.

(5) Prepare or secure printed material on conservation subjects for distribution by teachers in their schools.

(6) Secure the help of trained personnel of the colleges in research on watershed problems.

(7) Encourage local field study and conservation projects in all phases of natural resources, and

(8) Sponsor and encourage conservation contests approved by the schools especially in vocational agriculture classes.

Obviously, no matter how capable or enthusiastic he may be, the person representing the watershed organization should not supplant, but only assist, the teacher. Our students of today are the people of tomorrow. An interested student may become an ardent conservationist.

Cooperation with and from other agencies can be established by watershed organizations, if the agencies and the organizations will each make a reasonable effort to understand the other's problems, responsibilities, scope of activities, and interests. Frank, open inquiry and diplomacy will avoid duplication, conflicts, and misunderstanding, and will indicate how cooperation may result in great material benefit. Examples of this cooperation are the many County Agents of the Agriculture Extension Service, who have spearheaded watershed movements and on whom watershed organizations have relied for technical help.

In some instances, watershed organizations have initiated the formation of soil conservation districts; in others, the districts have started the watershed organizations. The latter have advertised, publicized, and promoted the districts and have secured financial assistance from business, industry, and municipalities, because the soil conservation districts, with their complete farm plan program and technical help from federal, state, and local agencies, have greatly accelerated the soil, water, and forest programs for the benefit of all. Throughout the country, there is probably no other agency whose help and cooperation has been as beneficial and necessary to the execution of sound watershed programs as the soil conservation districts.

Watershed organizations can cooperate most effectively with industry, business, utilities, and cities if the latter groups are a part of the watershed organization of the valley in which they are are located. In some instances, these groups have taken the initiative in forming watershed organizations and are major contributors thereto. Cooperation might take this course: business, industry, utilities, and municipalities contribute funds to the watershed organizations -- the organizations successfully promote conservation of soil, water, forests, etc. -- the production and income of farmers increase --

the farmers spend more money with business -- industry is benefited -- conservation practices improve water supply, benefiting cities, industries, and utilities -- in fact, everyone benefits, not immediately of course, but definitely in the long run.

Most utilities and chambers of commerce are interested in a long range program which will bring stability, security, and higher income to farm people in the area. However, many city people and industrialists do not understand and appreciate the importance of agriculture to the community and do not realize that soil and water conservation are essential to high production, high income, and stability of any community. Cooperation can be secured through a better understanding of these principles.

In many states watershed associations can be organized so as to qualify as sponsors for watershed protection projects under Public Law 566. Such states already have legislation providing for sanitary districts, drainage districts, water supply districts, water authorities, conservancy districts, flood control districts, or other types of official public bodies that can, through their powers of taxation, right of eminent domain, or other means, assure local participation financially or otherwise required by Public Law 566.

The enabling acts of some states provide soil conservation districts with sufficient authority to quality as sponsors, and the watershed organization can work through the soil conservation district or districts involved in the watershed. In other states where the watershed association may not itself be able to quality, it can work through municipalities, townships, counties or other political bodies which can qualify under Public Law 566.

The most common mistakes made by new watershed organizations are as follows:

(1) Starting with a group with but one single interest;

(2) Selecting for a leader or principal officer a person who, although aggressive, capable, and forceful, is for some reason not generally acceptable to the community;

(3) Inadequate initial financing;

(4) Failure to grasp the scope of the project and a tendency to minimize the work, expense, and support needed to accomplish the desired objectives;

(5) Lack of careful planning and failure to benefit by the experience of others who have spearheaded similar projects;

(6) Failure adequately to define objectives, specify responsibilities, and plan for action;

(7) Lack of recognition of other organizations and agencies that are already working on watershed programs;

(8) Inadequate public information, and

(9) Inadequate use of available local leadership.

The basic philosophy of watershed organizations as listed by the American Watershed Council is as follows:

1. A watershed is a logical unit on which to work in the conservation of natural resources because the people in a watershed have more in common than they do in most politically-bounded areas.

2. It should be the responsibility of the local people to initiate and carry out their own programs to completion.

3. A local watershed association should not duplicate other agencies but should secure the help of every local, state, and federal agency, and at the same time keep the control of all activities in local hands.

4. Constructive work on all natural resources should be carried on simultaneously, covering soil, forest, water, and wildlife resources, rather than concentrating on one natural resource.

5. The work in the watershed should be done for the benefits of all interests therein, and most of the costs should be borne by local people in proportion to the benefits received.

Views on Watershed Management by Federal Departments--The Secretary of Agriculture, the Secretary of the Interior, and the Secretary of the Army addressed the National Watershed Congress in the evening of December 6, 1954. Brief extracts from these addresses are as follows:

Secretary of Agriculture--There is an increasing interest in supplemental irrigation in the East. Federal agencies have a key position with respect to Public Law 566. It is the policy of the Department of Agriculture to cooperate with State agencies. The Soil Conservation Service is responsible for all land and water functions of the Department of Agriculture.

Provisions for watershed protection are contained in Public Law 566, the Water Facilities Act, and the Revenue Revision Act.

Public Law 566 provides permanent legislative machinery for establishing and aiding groups such as those now participating in the sixty pilot projects initiated under the original $5,000,000 appropriation. The pilot projects constitute a valuable testing program. Thirty seven States have provided legislative machinery for watershed protection under the provision of Public Law 566.

An amendment to the Watershed Facilities Act extends its provisions to the entire United States rather than the original seventeen Western States. The law makes possible loans by the Farmers Home Administration for a wide variety of water improvements on farms and ranges, including irrigation equipment.

Under a new provision in the Revenue Law, rural dwellers may consider soil conservation costs as current annual expenses deductible from income in figuring Federal taxes.

There is need for more research pertaining to watershed protection.

A combination of upstream improvement and downstream improvement is necessary. Upstream improvement is complementary to downstream improvement and vice versa.

The President has established a Cabinet Committee, consisting of the Secretary of the Interior, the Secretary of Defense, the Secretary of Commerce, the Secretary of Health, Welfare, and Education, and the Secretary of Agriculture, to establish a nation-wide water policy program.

No miracle is coming out of the Federal Treasury. The major share of the costs of watershed protection will be borne by local interests.

Secretary of the Army--Soil and water resources need to be used wisely. These resources are not inexhaustible. Positive action is necessary.

A reorganization of the Office of the Secretary of the Army has resulted in placing responsibility for navigation and flood control in the Office of the Assistant Secretary for Civil Military Affairs.

Progress has been made in connection with watershed protection. There are many problems to be solved. A greater degree of State and local participation is necessary. Active State and local organizations are of great importance.

The Corps of Engineers will do everything possible to coordinate flood control and watershed protection. There is no single panacea for flood problems and land treatment. Local protection work is a necessary adjunct.

State and local governments are responsible for doing everything within their means. The Federal Government will assist in planning and installation of protective works only when they are soundly integrated in the basin as a whole.

Division and District Engineers of the Corps of Engineers will work closely with State groups in watershed planning. The Department of the Army is intensely interested in watershed problems and in the activities of the National Watershed Congress.

Secretary of the Interior--The President's Cabinet Committee on Water Resources, of which the Secretary of the Interior is Chairman, will make an initial report to the President in the near future.

The water situation is desperate. Public Law 566 constitutes significant legislation. It emphasizes the importance of the upstream problem. It provides for a nation-wide program of conservation practices and furnishes pracical means for cooperation between Federal and local groups.

The Department of the Interior will provide information to the Department of Agriculture and to the Department of the Army. The Federal Government should take care of its own land, for which a 20-year development-program has been started.

North Carolina Soil Conservation Districts Law--The General Assembly of North Carolina during their 1937 Session enacted a Soil Conservation Districts Law. This act contains the legislative determination that it is necessary, in order to conserve soil resources and to control and prevent soil erosion, that land-use practices contributing to soil wastage and soil erosion be discouraged and discontinued, and that appropriate soil-conserving land-use practices be adopted and carried out. The land-use practices include the following:

(1) Construction of terraces, terrace-outlets, check-dams, dikes, ponds, and ditches;

(2) Utilization of strip cropping, lister furrowing, contour cultivating, contour furrowing, farm drainage, and land irrigation;

(3) Seeding and planting of waste, sloping, abandoned, or eroded lands with water-conserving and erosion-preventing plants, trees, and grasses;

(4) Forestation and reforestation;

(5) Rotation of crops;

(6) Soil stabilization with trees, grasses, legumes, and other thick-growing, soil-holding crops;

(7) Addition of soil amendments, manurial materials, and fertilizers for the corrections of soil defiencies and for promotion of increased growth of soil-protecting crops;

(8) Retardation of run-off by increasing absorption of rainfall; and
(9) Retirement from cultivation of steep, highly erosive areas, and areas now badly gullied or otherwise eroded.

The act sets forth the following declaration of policy: It is hereby declared to be the policy of the legislature to provide for the conservation of the soil and soil resources of the State, and for the control and prevention of soil erosion, and thereby to preserve natural resources, control floods, prevent impairment of dams and reservoirs, assist in maintaining the navigability of rivers and harbors, preserve wildlife, protect the tax base, protect public lands, and protect and promote the health, safety, and the general welfare of the people of this State.

The State Soil Conservation Committee--A State Soil Conservation Committee, consisting of three ex-officio members, the Director of the State Agricultural Extension Service, the Director of the State Agricultural Experiment Station, and the State Forester; and four other members, the President, first Vice-President, and immediate past President of the State Association of Soil Conservation District Supervisors, and a resident of North Carolina appointed by the Secretary of the United States Department of Agriculture, was established by the act.

Powers of the Committee--The act provides that the Committee shall have the following powers and duties:
(1) To offer such assistance as may be appropriate to the supervisors of Soil Conservation Districts in the carrying out of any of their powers and programs;
(2) To keep the soil conservation district supervisors informed of the activites and experience of all other districts, and to facilitate cooperation and an interchange of advice and experience between the districts;
(3) To coordinate the programs of the soil conservation districts;
(4) To secure the cooperation of the United States and any of its agencies, and of the agencies of this State, in the work of the districts; and
(5) To disseminate information throughout the State concerning the activities and programs of the Soil Conservation Districts, and to encourage the formation of such districts in areas where their organization is desirable.

Creation of Soil Conservation Districts--The act contains the following provisions regarding creation of soil conservation districts;
(1) Any twenty-five (25) occupiers of land lying within the territory proposed to be organized into a district may file a petition with the State Soil Conservation Committee, asking that a Soil Conservation District be organized to function in the territory described in the petition.

(2) Within thirty (30) days after such a petition has been filed with the Committee, it shall cause due notice to be given of a proposed hearing upon the question of the desirability and necessity, in the interest of the public health, safety, and welfare, of such district, and upon other pertinent matters.
(3) After such hearings, if the Committee shall determine, upon the facts presented at such hearing and upon such other relevant facts and information as may be available, that there is need, in the interest of the public health, safety, and welfare, for a Soil Conservation District to function in the territory considered at the hearing, it shall make and record such determination, and shall define, by metes and bounds or by legal subdivisions, the boundaries of such district.

(4) After the Committee has recorded such determination, it shall consider the question whether the operation of such district is administratively practicable and feasible. It shall hold a referendum within the proposed district upon the proposition of the creation of the district, and shall cause due notice of such referendum to be given. It shall publish the results of such referendum, and shall thereafter determine whether the operation of the district within the defined boundaries is administratively practicable and feasible.

(5) If such determination is favorable, the Committee shall appoint two temporary supervisors to act as the governing body of the district. These temporary supervisors shall serve until supervisors are elected or appointed, and have qualified, as provided in Sections 6 and 7 of the act. Such district shall be a governmental subdivision of the State and a public body corporate and politic, upon the taking of certain prescribed proceedings.

(6) After issuance by the Secretary of State of the certificate of organization of the Soil Conservation District, nominating petitions may be filed with the State Soil Conservation Committee not less than ten (10) nor more than sixty (60) days preceding the first day of election week as provided in Section 6 of the act, to nominate candidates for a Soil Conservation Committee in each county of the District to be composed of three (3) members. The State Committee shall pay all of the expenses of such election, shall supervise the conduct thereof, shall prescribe regulations pertaining thereto, and shall publish the results thereof. The duties of members of the County Committees are set forth in Section 6 of the act.

Section 7 of the act provides that the governing body of any soil conservation district shall consist of the Chairmen of the County Committees within the district, together with such additional supervisor or supervisors as may be appointed by the State Committee pursuant to Section 7 of the act, except that, when a district is composed of only one county, the members of the County Committee shall be members of the Board of Supervisors of the district which such county comprises, and prescribes certain administrative procedures of the governing body.

Powers of Soil Conservation Districts--Sections 8 and 9 of the act indicate the powers of Soil Conservation Districts and the supervisors thereof as follows:

(1) To carry out preventive and control measures within the district;

(2) To cooperate, or enter into agreements with, and, within the limits of appropriations duly made available to it by law, to furnish financial or other aid to, any agency, governmental or otherwise, or any occupiers of land within the district, in the carrying on of erosion-control and prevention operations within the district;

(3) To acquire, maintain, administer, improve, sell, lease, and otherwise dispose of, any property, real or personal;

(4) To make available, to land occupiers within the district, machinery, equipment, fertilizer, seeds, seedlings, and other material or equipment as will assist operations upon their lands for the conservation of soil resources and for the prevention and control of soil erosion;

(5) To construct, improve, and maintain structures;

(6) To develop conprehensive plans for conservation of soil resources and for the control and prevention of soil erosion;

(7) To act as agent for the United States in connection with soil-conservation, erosion-control, and erosion-prevention projects;

(8) To take specified legal actions;

(9) To require contributions from, and performance of agreements or covenants by, land occupiers; and

(10) To adopt regulations pertaining to necessary engineering operations, methods of cultivation, cropping programs, tillage practices, retirement of areas from cultivation, and other means, measures, operations, and programs as may assist conservation of soil resources and prevent or control soil erosion in the district.

Miscellaneous Provisions of the Act--Sections 10, 11, 12, 13, and 14 of the act provide for enforcement of land-use regulations, performance of work under the regulations by the supervisors, cooperation between districts, discontinuance of districts, and dividing of large districts, respectively.

Responsibility For Navigation-Improvement-- The Congress of the United States, in the River and Harbor Act of 1826, assigned responsibility for navigation-improvement to the Corps of Engineers, Department of the Army. This organization has been engaged in such work in North Carolina since 1828. The North Carolina coastal waters extending over 300 miles have been actively navigated for nearly four centuries. The outer banks, a long chain of narrow, barrier islands paralleling the coast, inclose wide, shallow sounds bordered by many harbors along the mainland shore. In these coastal waters and in the rivers which penetrate the interior, the Corps of Engineers has improved 1,100 miles of navigation channels, of which 41 miles are for deepdraft ocean vessels. More than $15,000,000 have been spent to construct channels and harbors for shallow-draft vessels, and $6,200,000 for deep-draft vessels. Commerce in shallow-draft vessels and in deep-draft ships, in 1951, totaled about 3,000,000 tons and about 4,900,000 tons, respectively.

Many of the channels and harbors for light-draft vessels transport fish and shellfish, as fishing is the most important activity in much of coastal North Carolina. Fishermen, and State and other governmental agencies, are vitally interested in the maintenance and improvement of channels and harbors for light-draft fishing vessels.

The major improvement for light-draft vessels in North Carolina is the Atlantic IntraCoastal Waterway which connects with all major navigation improvements in North Carolina and similar improvements along the entire Atlantic Seaboard.

Some of the inland navigation projects have carried little commerce recently. Those projects are mainly channels which had been cleared and snagged for navigation and on which no expenditures have been made for many years. They formerly carried large amounts of commerce and returned the small investments made for their improvement many times before the advent of good roads took most of their traffic.

Investigation, Planning and Construction of Projects - - In the planning and construction of the Corps of Engineers projects, other Federal, State, and local agencies advise and assist where their interests are affected. On some of the projects local interests are required to hold the United States free from damages, to furnish rights-of-way and spoil areas, and to furnish other assistance specified in the authorizing acts.

All new investigations of the Corps of Engineers are authorized by the Congress, usually at the request of the Congressional representatives from the locality concerned, directing the Secretary of the Army to cause the investigations to be made under the direction of the Chief of Engineers. The normal procedure is to first investigate a requested improvement by a preliminary examination, using such data as are readily available to determine whether a detailed survey is justifiable. If the preliminary examination is favorable, a survey is made in which maps, hydrographic charts, and other detailed information are prepared as required to determine the scope of the improvement, its cost, and its justification. The justification is determined and expressed as the value of a fraction, called the benefit-cost ratio, the numerator of which is the anticipated annual monetary benefits and the denominator is the estimated annual charges, both being based on the economic life of the project, usually assumed as 50 years. The benefits include savings in transportation costs by operation of deeper-draft

vessels, elimination of necessity for partial cargoes, and reduction in delays awaiting favorable tides. The charges include interest on the investment, amortization, and maintenance costs. The survey report, prepared by the District Engineer and containing a recommendation for or against the proposed improvement, is reviewed by the Division Engineer and considered by the Board of Engineers for Rivers and Harbors. Based on the report of the Board, the Chief of Engineers submits to the Secretary of the Army for transmission to the Congress his recommendation regarding the proposed improvement, accompanied by the comments and recommendations of the Governor of the State in the case of an intrastate project, or the Governors of the States concerned if the project is situated in two or more states.

The Chief of Engineers very seldom recommends the construction of a navigation improvement unless its benefit-cost ratio is greater than 1.0. If the proposed improvement is favorably considered by the Congress, it is incorporated in a river and harbor bill and thus becomes authorized for construction. The Congress have authorized only a small number of projects concerning which the Chief of Engineers has submitted an unfavorable report. The authorized projects are considered annually by the appropriations committees of the Congress. The projects which are approved for construction as a result of such consideration are included in appropriation enactments.

Action toward extension, enlargement, or other change in an authorized project, or re-investigation of a project, the report on which has been unfavorable, may be initiated by a resolution of the Congress requesting a review of the prior report or reports.

North Carolina Navigation-Improvements-- This chapter of Volume I will contain information regarding the North Carolina navigation-improvements which are not situated in any of the eleven major river basins. Information pertaining to other navigation-improvements may be found in the navigation chapters of subsequent volumes covering water resources of the Cape Fear, Neuse, Tar-Pamlico, and Chowan River Basins. The information indicated above will be set forth in the following order:
Completed Projects, Projects Under Way, Authorized Projects, and Preliminary Examinations and Surveys Under Way.

COMPLETED PROJECTS

KNOBBS CREEK

This project provides a channel 10 feet deep at mean low water, from that depth in Pasquotank River to the Norfolk Southern Railway bridge in Elizabeth City, 100 feet wide in Pasquotank River and generally 60 feet wide in the creek, with a turning basin in the bend. The project was completed in 1931 at a cost of $80,500.

The average annual commerce for the period 1947-1951 was 21,675 tons, and the commerce in 1951 about 22,000 tons. The chief commodities handled were logs and petroleum products.

NEWBEGUN CREEK

This creek rises in Pasquotank County and flows east about 5 miles to Pasquotank River, about 5 miles above its mouth in the northeastern part of

Albemarle Sound. This project provides for a depth of 5 feet and a minimum width of 40 feet over the bar at the confluence of the Creek and Pasquotank River, a distance of about 3,000 feet. It was completed in 1920 at a cost of about $4,800. The head of navigation is at the bridge on N. C. Highway No. 170 at Old Weeksville.

No commerce has been reported on Newbegun Creek in recent years.

PERQUIMANS RIVER

This project provides for a channel 1,000 feet long, 200 feet wide, and 9 feet deep through a reach 800 feet below Hertford, about 13 miles above the mouth of the river at the north central part of Albemarle Sound. The project was completed in 1910 at a cost of about $13,800. The head of navigation is at Newby's Bridge, about 5 miles above Belvidere.

The average tonnage of commodities moving over this waterway during the period 1947-1951 has been 8,200 tons, principally petroleum products. About 8,500 tons were transported through the channel in 1951.

EDENTON HARBOR

Harbor improvements provide for a channel 12 feet deep and 150 feet wide, from that depth in Edenton Bay, in the northwestern part of Albemarle Sound, a distance of about 4,000 feet to Edenton, and channels of the same depth and width 900 feet east and 1,600 feet west along the waterfront. The project was completed in 1931 at a cost of about $73,800. The west channel may connect at some time in the future with the authorized Pembroke Creek channel to the United States Fish Hatchery. Information regarding this channel may be found hereafter in this chapter under "Authorized Projects".

Total waterborne commerce in Edenton Harbor for the period 1947-1951 has averaged about 12,900 tons annually, principally petroleum products. Commerce in 1951 totaled about 12,200 tons.

MACKAY CREEK

The project provides for a channel 9 feet deep and 100 feet wide from deep water in the southwest side of Albemarle Sound across the bar, a distance of 2,200 feet, and for the removal of obstructions, between the Sound and the Town of Mackeys, a distance of about 3,300 feet. The project was completed in 1932 at a cost of about $13,400.

Average annual water-borne traffic during the period 1947-1951 has been 438 tons, principally pulpwood and fish; in 1951 the commerce was 615 tons.

SCUPPERNONG RIVER

This project consists of a shallow-draft channel from deep water in Bull Bay at the south central part of Albemarle Sound and northwest of the town of Columbia, to the town of Cherry, a total distance of about 20 miles. The project provides for a channel 10 feet deep and 150 feet wide over the bar; 10 feet deep and 100 feet wide from the upstream end of the bar channel to Columbia; 8 feet deep and 40 feet wide to Spruills Bridge, near Creswell, including six cutoffs; and 7 feet deep and 30 feet wide to the highway bridge near Cherry; and a triangular turning basin 7 feet deep by 150 feet on a side, near Cherry Bridge, at the mouth of Mauls Creek. The project was completed in 1925 at a cost of

about $81,200.

Water-borne commerce, principally petroleum products and pulpwood, averaged about 32,200 tons annually in the period 1947-1951; 86,100 tons were transported in 1951, including over 57,000 tons of gravel for roadwork.

STUMPY POINT BAY

This project consists of a channel 7 feet deep and 75 feet wide from deep water in Pamlico Sound through Stumpy Point Bay, in the northern part of the Sound, to Lake Worth, a distance of about 8,000 feet; and a boat basin of the same depth, 50 feet wide and 600 feet long at the inner end. The project was begun in May 1950 and completed during the following month at a cost of about $40,600.

Water-borne traffic for 1950 was 266 tons and for 1951 it was about 328 tons, consisting principally of sea food.

BELHAVEN HARBOR

The project provides for a channel 12 feet deep and 100 feet wide, extending from Pungo River, which includes a part of the Atlantic Intracoastal Waterway and discharges into the northwestern part of Pamlico Sound near the mouth of the Pamlico River, up Pantego Creek to a point about 800 feet east of the N. C. Highway 92 bridge over Pantego Creek at Belhaven, with a turning basin 800 feet by 300 feet at the upper end; and for the construction of timber breakwaters at the mouth of Pantego Creek.

Dredging was completed in 1931 and the breakwaters in 1940 at a cost of about $126,700. Further improvements of Belhaven Harbor under consideration are described hereafter in this chapter under "Preliminary Examinations and Surveys Under Way".

Water-borne commerce during the period 1947-1951 averaged 19,710 tons annually over this waterway, principally logs, petroleum products, and various sea foods. In 1951 commerce totaled about 17,500 tons.

CHANNEL FROM PAMLICO SOUND TO AVON

The project consists of a channel 6 feet deep and 100 feet wide from Pamlico Sound to the town of Avon, on the sound side of the barrier beach about 9 miles north of Cape Hatteras, with a basin of the same depth, 100 feet by 300 feet, at Avon. The project was completed in October 1946, at a cost of $28,000.

Annual water-borne commerce averaged about 2,050 tons during the period 1947-1951. The most important commodity handled was sea food. Commerce totaled about 1,980 tons in 1951.

SILVER LAKE HARBOR

Silver Lake Harbor is at the westerly end of Ocracoke Island, a portion of the barrier separating Pamlico Sound from the Atlantic Ocean, about 50 miles northeast of Beaufort and about 60 miles southeast of Belhaven. This project provides for a channel, 10 feet deep and about one and one-half miles in length, from deep water in Pamlico Sound to and including an anchorage basin of the same

depth in Silver Lake Harbor at the Town of Ocracoke, with widths of 100 feet across Big Foot Slough bar and 60 feet in the entrance channel; and a training wall 300 feet long to protect the outer end of the entrance channel from northeast storms. The project was completed in 1942 at a cost of about $67,200.

The average annual water-borne commerce for the period 1947-1951 was 3,680 tons, principally petroleum products and fish. In 1951 such commerce totaled about 2,850 tons.

DRUM INLET

Drum Inlet is an opening through the barrier beach which separates Core Sound from the Atlantic Ocean. It is about 1,100 feet wide and is about 35 miles northeast of Beaufort and opposite the Town of Atlantic in Cartaret County. This project provides for a channel 12 feet deep and 200 feet wide from the gorge in the inlet to the Waterway (in Core Sound) connecting Pamlico Sound and Beaufort Harbor. (Information regarding this waterway may be found hereafter in this chapter under "Projects Underway -- Light-Draft Channels".) The Drum Inlet project was completed in 1940 at a cost of $52,800.

The average annual commerce during the period 1947-1951 was 198 tons, all fish and shellfish. Commerce in 1951 totaled 110 tons.

SHALLOTTE RIVER

The project provides for a channel, 4 feet deep, 36 feet wide, and about 9 miles long, from the Atlantic Ocean through Shallotte Inlet and up the Shallotte River to the town of Shallotte in Brunswick County. The downstream end of the channel is about 20 miles west of the mouth of the Cape Fear River. The project was completed in 1929 at a cost of about $15,200.

The average annual water-borne traffic on this waterway in the period 1947-1951 was 396 tons, principally sea food. Commerce in 1951 totaled 474 tons.

Projects Under Way--Light-Draft Channels

Atlantic Intracoastal Waterway between Norfolk, Virginia, and Little River, South Carolina.

This waterway is a sea-level route through coastal sounds and marine marshes, paralleling the Atlantic coast. Two routes are available from Norfolk to Albemarle Sound, one through the Dismal Swamp Canal and into the Pasquotank River and the other through the Virginia Cut into Currituck Sound and thence through another land cut into North River. The former has a controlling depth of 9 feet. By the Albemarle and Chesapeake Canal route the project provides for a waterway 12 feet deep, with widths varying from 90 feet in land cuts to 300 feet in open waters, with the following features:

Operation and maintenance of suitable bridges

A tidal lock in Snow's Cut near the Cape Fear River

A channel 12 feet deep and 90 feet wide in New River between the Intracoastal Waterway and the Atlantic Coast Line Railroad Bridge at Jacksonville, 21 miles, and a basin at Jacksonville

A side channel 12 feet deep and 90 feet wide to a turning basin 200 feet by 350 feet at Swansboro

An entrance channel 6 feet deep and 90 feet wide at New River Inlet, with a connecting channel of same dimensions to the Intracoastal Waterway

Six (6) mooring basins at various locations along the waterway
A channel 14 feet deep and 400 feet wide across the ocean bar at Masonboro Inlet, thence 12 feet deep by 90 feet wide to the Intracoastal Waterway at Wrightsville via Banks and Motte Channels
A turning basin 5 feet deep and 300 feet by 700 feet on the east side ofBanks Channel near Masonboro Inlet
A jetty on each side of Masonboro Inlet extending to the 4-foot contour in the ocean
A basin 12 feet deep, 230 feet by 450 feet, near Southport
Salt-water-intrusion preventative measures and improvement of drainage in thevicinity of Fairfield by construction of a dam and pumping plant and improvements in other canals in the area.

The project is about 91 per cent completed. Total Federal costs to January 1, 1953 amounted to $9,401,800 for new work.

No work has been done on providing a tidal look in Snow's Cut, six mooring basins, a 12-foot channel in New River, dredging in Masonboro Inlet and connecting channels, and jetties at Masonboro Inlet. The Rivers and Harbors Appropriation Act for the Fiscal Year ending June 30, 1955 provided funds in the amount of $195,000 to accomplish the salt-water-intrusion preventative measures in the vicinity of Fairfield. Local interests have arranged to provide the required cooperation for this feature, and construction thereof is expected to be initiated in the immediate future. The estimated cost to complete the project, including the dam, pumping plant, and canal improvements near Fairfield, is estimated to be $2,465,400.

The total average annual commerce over this waterway during the period 1947-1951 was 1,201,080 tons, consisting of petroleum products, logs and pulpwood, fish and shellfish, and various other commodities. Commerce totaled about 1,478,500 tons in 1951. This waterway served as a vital artery for transportation during the recent war. Pleasure craft make extensive use of this waterway.

MANTEO (SHALLOWBAY) BAY

This bay is on the northeast side of Roanoke Island, about 13 miles northwest of Oregon Inlet, the northernmost existing inlet through the barrier beach from the ocean. The existing project, only about 7 per cent completed, provides for the following channels which, when completed, will have a total length of about 25 miles:

A channel 14 feet deep and 400 feet wide from the Atlantic Ocean over the bar and through Oregon Inlet, thence 12 feet by 100 feet via Old House Channel to that depth in Pamlico Sound
A channel 12 feet by 100 feet from Oregon Inlet to and including a turning basin 12 feet deep, 200 feet by 600 feet, at Manteo
A side channel 12 feet by 100 feet from the Manteo-Oregon Inlet Channel in Roanoke Sound to wharves in Mill Creek near Wanchese, including a turning basin 200 feet square
A connecting channel of 6 feet by 100 feet from the Manteo-Oregon Inlet Channel in Roanoke Sound to that depth in Albemarle Sound.

The 6-foot channel from Roanoke Sound to Manteo was completed in 1911, and a 6-foot channel to Oregon Inlet was dredged in 1941. No work has been done on the 14-foot channel from the ocean through Oregon Inlet, nor the 12-foot channels from Oregon Inlet to Manteo, Pamlico Sound, and Mill Creek, nor the basins included

in the project. The completed work has cost $63,400. The estimated cost for the remaining work is $1,104,800.

Total average commerce over this waterway during the period 1947-1951 was 16,800 tons, principally petroleum products. Commerce in 1951 totaled 15,730 tons. When the project is completed, it is expected that the commercial fishing industry will be greatly expanded with a corresponding increase in the transport of fish and shellfish.

FAR CREEK

Far Creek, in Hyde County, flows into Pamlico Sound about 95 miles south of Norfolk, Virginia. The project provides for a channel 12 feet deep and 100 feet wide from that depth in Pamlico Sound into the estuary, a distance of about 1.9 miles, thence 12 feet deep and 80 feet wide to about 200 feet below the highway bridge in Engelhard, a distance of about 4,200 feet, with a turning basin of same depth about 200 feet by 900 feet at the head.

The project is about 25 per cent completed. A 7-foot channel was completed in 1931. No work has been done on increasing the depth of the channel and basin to 12 feet. The cost of the 7-foot channel was $34,500. It is estimated that the remaining work will cost $100,000.

The average annual commerce over this waterway for the period 1947-1951 was 29,640 tons, principally petroleum and sea food with the exception of 61,000 tons of sand and gravel for road work in 1947 and 47,250 tons of sand and gravel in 1950. Commerce in 1951 when no sand and gravel was transported totaled about 5,900 tons. When the project is completed it is expected that commerce, particularly in grain and soybeans, will greatly increase.

WATERWAY CONNECTING SWANQUARTER BAY WITH DEEP BAY

The project consists of two parts, the connection between Swan Quarter Bay and Deep Bay, and the entrance channel to the Town of Swan Quarter, the county seat of Hyde County, and provides for a channel 60 feet wide and 8 feet deep from Deep Bay through the present waterway to Swan Quarter Bay, and thence through the Swan Quarter Canal to a basin of the same depth about 500 feet long, and 60 to 300 feet wide, at the head of the canal. A channel 6 feet deep between Swan Quarter Bay and Deep Bay was completed in 1911 at a total cost of about $8,600. The estimated cost of the remainder of the project is $50,000.

The average annual commerce for the period 1947-1951 amounted to 2,490 tons, principally fish, shellfish, and petroleum products. Commerce in 1951 totaled 771 tons.

ROLLINSON CHANNEL

This project provides for a channel 100 feet wide and 6 feet deep from Pamlico Sound to and including a basin at the Town of Hatteras, on the outer bank northeast of Hatteras Inlet and southwest of Cape Hatteras. The 6-foot channel, 100 feet wide, from deep water in Pamlico Sound to the natural inner basin was completed in 1936 at a total cost of about $20,100. No work has been done on the extension of the 6-foot channel to and including the basin at the Town of Hatteras, the estimated cost of which is $55,000.

The average annual commerce for the period 1947-1951 amounted to 6,670 tons, principally fish, shellfish, and petroleum products. Commerce in 1951 totaled about 4,280 tons.

Further improvements of the channel under study may be found hereafter in this chapter under "Preliminary Examinations and Surveys Under Way".

CHANNEL CONNECTING THOROUGHFARE BAY WITH CEDAR BAY

Thoroughfare Bay is situated along the outer bank between Drum Inlet and Ocracoke Inlet. Cedar Bay lies in the southern part of Pamlico Sound about 15 miles southeast of the Town of Oriental. The project provides for a channel 7 feet deep and 50 feet wide, with increased width at bends, to connect Thoroughfare Bay and Cedar Bay. The channel is approximately 4 miles long. The existing 5-foot channel, 50 feet wide, was completed in 1951 at a total cost of $9,000. The estimated cost of increasing the depth from 5 feet to 7 feet is $30,000.

The average annual commerce for the period 1947-1951 amounted to 1,490 tons, principally fish and shellfish. Commerce in 1951 totaled about 1,625 tons.

WATERWAY CONNECTING PAMLICO SOUND AND BEAUFORT HARBOR

This waterway begins at the southeast corner of Pamlico Sound, passing southwest through Wainwright Slough, Core Sound, and the Straits, to Beaufort Harbor, a total length of 33.9 miles. The project provides for the following channels:

- A channel 7 feet deep and 75 feet wide from Pamlico Sound to Beaufort Harbor via Wainwright Slough, Core Sound, and the Straits.
- An alternative route of the same width and depth through Back Sound via channels at the east and west ends of Harkers Island
- A channel 7 feet deep and 75 feet wide from the main channel in Core Sound to the Town of Atlantic.
- A side channel 5 feet deep, 75 feet wide, with a basin 150 feet by 130 feet, same depth, at the town of Davis
- A side channel 7 feet deep, 75 feet wide, with a basin 200 feet by 500 feet, same depth, at the Town of Sealevel
- A side channel 6 feet deep, 60 feet wide, from the 6-foot contour in the Straits to a basin 100 feet by 600 feet, same depth at the Town of Marshallberg.

The portion of the project providing for a through channel from Pamlico Sound to Beaufort Harbor was completed in 1934, the side channel to Atlantic was completed in 1937, and the side channel and basin at Davis was completed in 1948, at a total cost of $91,400. No work has been done on the alternative route through Back Sound, the side channel and basin at Sealevel, and the side channel and basin at Marshallberg. The estimated cost of the remaining work is $131,600.

Commerce, almost entirely fish and shellfish, totaled 12,137 tons in 1950 and about 9,790 tons in 1951.

BEAUFORT HARBOR

This harbor is just inside Beaufort Inlet adjacent to Morehead City Harbor. The project provides for the following features:

Stopping erosion at the inlet by jetties and sand fences at Fort Macon and Shackleford Points, and other shore protection

A channel 12 feet deep, 100 feet wide, in Bulkhead and Gallants Channel 600 feet wide in front of the Town of Beaufort

A channel 12 feet deep and 100 feet wide, about 2.6 miles long, from a point opposite the foot of Marsh Street, in Beaufort, through Taylors Creek to Lennoxville Point at North River

A stone bulkhead from Town Marsh across Bird Shoal to Carrot Island

The distance from the inlet to the upper end of Gallants Channel is about 5 miles.

The deepening of Bulkhead and Gallants Channels and the basin in front of Beaufort was completed in 1931. No work has been done on increasing the width and length of the basin in front of Beaufort nor deepening the 7-foot channel in Taylors Creek to 12 feet. Costs of the work done on the project amount to $269,700. The estimate of cost for remaining work is $154,200.

Taylors Creek was a part of the waterway connecting Pamlico Sound and Beaufort Harbor prior to 1950. Commerce in Beaufort Harbor, including commerce over Taylors Creek, totaled 38,595 tons in 1950 and about 32,000 tons in 1951. The average volume of commerce in Beaufort Harbor for the period 1947-1951, adding the commerce over Taylors Creek when it was a part of the waterway referred to above, was nearly 40,000 tons. The commerce consists principally of fish and shellfish.

CHANNEL FROM BACK SOUND TO LOOKOUT BIGHT

This project provides for a channel from deep water in Back Sound, from a point on the waterway connecting Pamlico Sound and Beaufort Harbor near the eastern end of Harkers Island and about 8 miles east of Beaufort, through the shallow waters of Back Sound and Lighthouse Bay, to and through Shackleford Banks, and into the Atlantic Ocean at Lookout Bight. A channel, 5 feet deep and 50 feet wide, was completed in 1938 at a total cost of about $24,700. No work has been done on increasing the depth to 7 feet and the width to 100 feet, the estimated cost of which is $105,000.

The average annual commerce for the period 1947-1951 amounted to 2,930 tons, principally fish and shellfish. Commerce in 1951 totaled 448 tons.

HARBOR OF REFUGE - CAPE LOOKOUT

This project provides for a harbor of refuge, inclosing by means of a rubblestone breakwater 7,050 long an area of 575 acres of 30 or more feet in depth. A breakwater 4,800 feet long was constructed in 1917 at a cost of $1,368,800.

The harbor is not extensively used, and the Corps of Engineers considers that neither completion of the project at a cost of $8,800,000 nor maintenance of the completed portion is essential.

LOCKWOODS FOLLY RIVER

The project provides for a channel 100 feet wide and 6 feet deep, from the Atlantic Ocean through Lockwoods Folly Inlet, which is about 12 miles west of the mouth of the Cape Fear River, around the southern and eastern sides of Sheep Island, and up the Lockwoods Folly River to the bridge on N. C. Highway No. 130 at the Town of Supply in Brunswick County, 19 miles above.

No work has been done on this project since 1897, when the project was about 33 per cent completed at a cost of $17,800. Completion of the project is estimated to cost $147,000. The Corps of Engineers has found it impracticable to provide a 6-foot channel through Lockwoods Folly Inlet. Further improvements under study may be found hereafter in this chapter under "Preliminary Examinations and Surveys Under Way, Holden Beach".

The average annual commerce for the period 1948-1951 amounted to 74 tons, all fish and shellfish. The average annual commerce for the 6-year period prior to 1948 was 20,100 tons, principally pulpwood. Commerce in 1951 totaled 61 tons of fish and shellfish.

PROJECTS UNDER WAY -- DEEP-DRAFT CHANNELS

WILMINGTON HARBOR

Information regarding this harbor may be found in a subsequent volume, "Water Resources of the Cape Fear River Basin".

MOREHEAD CITY HARBOR

The project provides for the following features:

A channel 30 feet deep and 400 feet wide across the ocean bar at Beaufort Inlet, thence same depth and 300 feet wide to the terminals at Morehead City, enlarged to 600 feet to form a turning basin at that point

Construction of jetties at the inlet

A channel 12 feet deep and 100 feet wide from the 30-foot channel to Sixth Street, Morehead City, thence same depth and 200 to 400 feet wide to Tenth Street, thence 6 feet deep and 75 feet wide to deep water in Bogue Sound.

The portion of the project providing for a 12-foot channel to Morehead City, thence a 6-foot channel westward to Bogue Sound, was completed in 1931; the portion providing for the 30-foot channel to the terminals was completed in 1936. No work has been done on the jetties provided for Beaufort Inlet. Costs of work done on the project have been $613,100. The estimated cost of the remaining work is $2,875,000. Information regarding further improvements under study may be found hereafter in this chapter under "Preliminary Examinations Under Way".

The commerce for the period 1947-1951 averaged 258,690 tons annually, principally petroleum products. Commerce in 1951 totaled about 344,000 tons. In view of the construction of modern port facilities at Morehead City Harbor, it is anticipated that the annual commerce of the port will increase considerably.

AUTHORIZED PROJECTS

PEMBROKE CREEK

This creek extends from its mouth in Edenton Bay at Edenton, northwest and north about nine and one-half miles above. The project provides for a channel 12 feet deep and 80 feet wide from the improved channel in Edenton Bay upstream 500 feet, and thence 8 feet deep and 50 feet wide to the United States Fish Hatchery, 2/3 of a mile above the mouth. No work has been done on the project, the estimated cost of which is $15,000.

No commerce has been reported on this waterway. The project would primarily serve the needs of the Fish Hatchery.

CHANNEL FROM PAMLICO SOUND TO RODANTHE

The Town of Rodanthe is on the barrier beach between Pamlico Sound and the Atlantic Ocean, about 25 miles north of Cape Hatteras and 15 miles south of Oregon Inlet. The project provides for a channel 6 feet deep and 100 feet wide from that depth in Pamlico Sound to the shore, with a basin at the shore end, 80 to 100 feet wide and a total length of about 1,200 feet. No work has been done on the project, the estimated cost of which is $45,000.

Average annual commerce for the period 1947-1951 was 1,950 tons, principally fish, shellfish, and petroleum products. Commerce in 1951 totaled about 1,620 tons.

PRELIMINARY EXAMINATIONS AND SURVEYS UNDER WAY

ATLANTIC INTRACOASTAL WATERWAY BETWEEN

NORFOLK, VIRGINIA, AND LITTLE RIVER, SOUTH CAROLINA

An investigation of this project, to determine the advisability of providing a side channel to Elizabeth City via Albemarle Sound and Pasquotank River so that small tankers and freighters sailing the Intracoastal Waterway could make deliveries to Elizabeth City, was reported by Division Engineer, South Atlantic Division, Corps of Engineers, as of January 1, 1953 to be scheduled for completion by the District Engineer, Norfolk District, in February 1953.

Considerable field and office work on an investigation of that part of the Atlantic Intracoastal Waterway between Albemarle Sound and Pungo River, to determine the advisability of measures to provide adequate drainage and protect farm and timber lands affected directly by the Waterway, has been done by the District Engineer, Wilmington District. Completion of his report on this investigation has been deferred by lack of funds.

As a result of the investigation to determine the advisability of providing a channel from the Intracoastal Waterway in Bogue Sound into Peltier Creek, a 12-foot-deep channel has been recommended by the Chief of Engineers (House Document No. 379, 81st Congress, 1st Session). The report of the Chief of Engineers regarding this proposed project was submitted to the Congress by the Secretary of the Army on October 18, 1949. As of January 1, 1953, the project had not been authorized.

BOGUE INLET AND SWANSBORO HARBOR

The completion of an investigation of the feasibility of providing navigation improvements in Bogue Inlet and Swansboro Harbor, Onslow County, is indefinite.

IMPROVED CHANNEL FROM ROANOKE RIVER ALBEMARLE SOUND

The completion of an investigation of the feasibility of providing an improved channel from Roanoke River, either by way of The Thoroughfare and lower Cashie River, or Middle River, and Batchelor Bay, or by any other route, is indefinite.

BELHAVEN HARBOR

As a result of the investigation to determine the advisability of providing a side channel and boat basin, and modification of existing breakwaters, in Belhaven Harbor, a channel in Wynne's Gut has been recommended by the Chief of Engineers (House Document No. 389, 82nd Congress, 2nd Session). The report of the Chief of Engineers regarding this proposed modification of the existing project was submitted to the Congress by the Secretary of the Army on February 26, 1952. As of January 1, 1953, the modification had not been authorized.

MIDDLE CREEK, HYDE COUNTY

The completion of an investigation by the District Engineer, Wilmington District, of a proposed improvement in this creek near the Town of Englehard, about two and one-half miles east of Mattamuskeet Lake, is indefinite. As of January 1, 1953, the type of improvement desired was undetermined, pending the holding of a public hearing.

CAPE CHANNEL, PAMLICO SOUND

The completion of an investigation by the District Engineer, Wilmington District, to determine the feasibility of providing a deeper channel from Pamlico Sound to the Town of Buxton, on the outer barrier near Cape Hatteras, is indefinite.

CHANNEL FROM HATTERAS INLET TO HATTERAS AND BREAKWATERS FOR ROLLINSON CHANNEL

As of January 1, 1953, the Division Engineer, South Atlantic Division, had submitted to the Chief of Engineers the report of the District Engineer, Wilmington District, on an investigation to determine the feasibility of providing a deeper channel from Hatteras Inlet to the Town of Hatteras, and breakwaters for the entrance to the harbor at Hatteras.

CROSS ROCK CHANNEL - WALLACE CHANNEL

The purpose of this investigation was to determine the advisability of improvement of Cross-Rock Channel from Wallace Channel to Sheep Island Slue and

the maintenance of Wallace Channel as an alternative route. An interim survey report on Wallace Channel, submitted to the Congress by the Secretary of the Army on Jan. 17, 1950, (House Document No. 453, 81st Congress, 2nd Session), recommended adoption of Wallace Channel as a Federal project. A preliminary examination report, submitted to the Congress on September 5, 1950, recommended against a survey of Cross-Rock Channel.

SMITHS CREEK, PAMLICO COUNTY

The purpose of this investigation was to determine the advisability of constructing a breakwater and deepening the harbor at the Town of Oriental. A 10-foot depth project and a rubble-mound breakwater has been recommended by the Chief of Engineers. A copy of the report of the Chief of Engineers was submitted to the Bureau of the Budget by the Secretary of the Army on June 27, 1952.

CHANNEL FROM PAMLICO SOUND THROUGH CORE SOUND TO BEAUFORT HARBOR

The completion of an investigation to determine the feasibility of providing a boat basin either in the natural identation at the west end of Harkers Island or along the south shore of the island is indefinite.

MOREHEAD CITY HARBOR

The Chief of Engineers has prepared his report on an investigation to determine the feasibility of providing enlargement of the turning basin and increased depths in the basin and in the present 30-foot deep channel.

TOPSAIL INLET

The completion of an investigation of this inlet is indefinite. The type of improvement desired is undetermined, pending the holding of a public hearing.

CAROLINA BEACH

As of January 1, 1953, a preliminary examination report on an investigation to determine the advisability of improvements for navigation, pollution abatement, and commercial fishing was scheduled to be submitted in Fiscal Year 1953.

As of January 1, 1953, a cooperative beach erosion study to investigate the feasibility of improvements for checking beach erosion was scheduled to be completed in Fiscal Year 1953.

HOLDEN BEACH

As of January 1, 1953, a preliminary examination report on an investigation, to determine the advisability of providing a boat basin at Holden Beach and improvements of Lockwoods Folly Inlet for navigation, principally commercial

fishing, and prevention of beach erosion, was scheduled to be submitted in Fiscal Year 1953.

SHALLOTTE RIVER

The completion of an investigation of requests for a deeper channel over the ocean bar and in the river is indefinite.

North Carolina Inlets - - The inlets through the Outer Banks of North Carolina constitute water resources of great importance to the welfare of the people of Eastern North Carolina. In fact, the livelihood of many of them depends upon adequate navigation through these inlets.

The "Report on Survey of North Carolina Inland Ports and Waterways", prepared for the North Carolina Department of Conservation and Development by Parsons, Brinckerhoff, Hall and McDonald, Engineers, New York, 1954, contains the following statements regarding inlets and their navigability, stability, and use.

Perhaps no other single factor has, or will have, more influence upon the social and economic development of Eastern North Carolina than the land and water conformations of the Coastal Plain. The outer shoreline has a length of 330 miles, almost all of which consists of barrier reefs or beaches separated from the mainland by lagoons or sounds. Although nearly continuous, this barrier is broken by many tidal inlets which connect the inner waters with the ocean. The inlets have a long history of migration, closure, and reopening. Severe storms frequently breech these barriers, even though they may be from a few hundred feet to several miles wide. They are composed principally of sand with, in some reaches, dunes averaging from 10 to 20 feet in height, and a few exceeding 75 feet up to a maximum of 168 feet. There is a general southward littoral drift of sand from the beaches. Many of the Outer Banks were once well-wooded or grassed-over. They are now generally denuded, resulting in decreased stability and shifting of the dunes.

Since the inlets are the only waterway connections between the Atlantic Ocean and the sounds, and are important in maintaining proper conditions of salinity required for optimum propagation of both fish and shellfish in the interior water, the condition and permanency of these inlets is of vital importance to the present and future economy of the Coastal Plain.

Inlets are usually opened by storms either through frontal attack or by the sudden buildup of wind tides and waves against the seaward shores of the broader sounds. Tidal flow and watershed discharge during ebb flow tend to keep inlets open. This effect is correspondingly reduced if additional nearby inlets develop, thus diverting part of the total flow. This reversing flow tends to build up submerged tidal deltas at both the ocean and sound ends of the inlet gorge.

Inlets may close suddenly as the result of severe storms which cause major displacements of material, or gradually through an excess of littoral drift over the capacity of inlet flow to cut through the debris moving across the seaward opening.

The North Carolina Coast has at present 24 natural open inlets. Their names in order from North to South are as follows: Oregon, Hatteras, Ocracoke, Sand Island, Drum, Barden, Beaufort, Bogue, Bear, Brown's, New River, New Topsail, Old Topsail, Rich, Mason, Moore, Masonboro, Corncake, Cape Fear River, Lockwoods Folly, Shallotte, Tubbs, Mad, and Little River.

In addition to the 24 inlets listed above as now open, local interests at Carolina Beach expended in 1952 about $18,000 to dredge a small connecting channel through the barrier between Myrtle Sound and the ocean, about 3 miles north of Carolina Beach. This 6-foot channel was extended seaward from the low water line by blasting operations at the beginning of ebb tide so as to obtain maximum scour through the ocean bar. At last reports depths through the barrier cut appeared to be holding well. Some shoaling has occurred, however, in the ocean bar section, and local interests were planning, as of July 1, 1954, to use a drag or plow on a tow line in an attempt to concentrate the flow into the cross-bar pilot channels. In addition to providing passage for small boats, the cut was intended to restore salinity conditions in Myrtle Sound in connection with shellfish propagation.

Old charts show 17 other inlets with varied records of opening and closing, usually as a result of major storms. During the period between 1585 and 1954 only three inlets between Cape Henry and Cape Lookout-Oregon, Hatteras, and Ocracoke-have remained open at all times. (The map of the State of North Carolina, U.S. Geological Survey in cooperation with the State of North Carolina, reprinted 1926, shows the following inlets not named above: New and Loggerhead, between Oregon and Hatteras, and Whalebone, between Ocracoke and Beaufort. Locations of Sand Island, Drum, and Barden Inlets are not shown on this map.)

Also, as evidenced where reliable survey data is available, the inlets tend to migrate, usually down coast toward the south and west. Oregon Inlet moved about 7000 feet in the 66-year period of 1850-1916. Marked beach and offshore changes have gone on concurrently with extensive areas of erosion and accretion. Typical of these changes is New Inlet, about 10 miles south of Oregon Inlet. After being open for many years, it was closed by a storm in January 1922. An attempt was made to reopen it artificially in 1924. It remained open, however, for only a few months. It was again reopened by the storm of March 6, 1932. During the next few years, it migrated about one-half of a mile, by successive southward shifts, with concurrent changes in width of opening until by 1947 it had again closed entirely.

It is evident from the above that attempts to dredge new, or maintain old inlets, may be in direct opposition to intensive and usually unpredictable natural forces. Up to the present no attempts have been made to stabilize these inlets by jetties. The construction of jetties at Masonboro Inlet at a 1949 estimated cost of $1,590,000 has been authorized by the Congress, provided that it proves impractical to maintain the bar channel by dredging alone. (As indicated above under "Projects Under Way--Light-Draft Channels", no work has been done on dredging in Masonboro Inlet and connecting channels).

Many so-called improved waterways have controlling depths sometimes considerably less than those officially authorized. Also, even the latter are in some cases fixed at 5 and 6 feet. Channels of these depths are critically close to the loaded draft of the smaller and medium-sized fishing boats. They would prohibit the passage of the larger trawlers. All too frequently, the shortest route will contain one or more reaches with restrictive channel depths. This may mean considerable detouring and the traverse of relatively open water within the sounds, or a much longer run to another inlet if the boats are working the off-shore waters.

Not only are there many natural and improved channels at or near a critical depth for a particular craft, but wind tides within the sounds may change these depths by as much as two or three feet. In attempts to reduce running costs as well as the danger of cargo spoilage, the boat operators are prone to take calculated risks in their choice of passage, with occasional groundings inevitable. Sometimes

they do not have the privilege of exercising a choice when caught by sudden storms or the threat of bad weather. It is quite understandable that the fishermen are constantly urging the deepening of existing channels and the dredging of new cut-offs. (The fishermen, boat operators, and other persons in Brunswick County are urging the deepening of Lockwoods Folly and Shallotte Inlets in order to provide adequate navigation through these inlets).

During the early improvements of North Carolina waterways, not only were outlets to the sea restricted as to numbers and controlling depths but, as previously noted, the migration of Outer Banks inlets and the instability of barrier reefs made it impractical to provide dependable channels at these openings, particularly with the equipment then available. In fact, even with modern engineering facilities, inlet stabilization is usually prohibitively expensive and generally entails subsequent high maintenance costs.

The "Report on Survey of North Carolina Inland Ports and Waterways" contains the following conclusions regarding inlets.

(1) Existing inlets will be unstable in the future as they have been in the past.
(2) Stabilization of these inlets cannot be effected at reasonable cost.
(3) New inlets will open, migrate and eventually close. The only measures considered to be practicable in effecting partial control of inlet changes comprise the construction of dunes to prevent breaching at low sections where new inlets are not desired, and dry excavation at low sections to facilitate breaching during storms where inlets are desired.

The North Carolina Department of Conservation and Development does not concur in the above conclusions. It is believed that some of the existing inlets will be stabilized in the future by the construction of jetties or by the operation of sand transfer facilities. If stabilization of an inlet can not be effected at reasonable cost, it is believed that the Chief of Engineers would not have recommended, and the Congress would not have authorized, a channel 14 feet deep and 400 feet wide across the ocean bar at Masonboro Inlet and a jetty on each side of Masonboro Inlet extending to the 4-foot contour in the ocean, as indicated above under "Projects Under Way--Light-Draft Channels, Atlantic Intracoastal Waterway between Norfolk, Virginia, and Little River, South Carolina". Local interests should not be given the impression that the Beach Erosion Board, the Chief of Engineers, and the Congress approve the opening of an inlet unless such opening is caused by the forces of nature or is a result of authorization and appropriation by the Congress upon the recommendations of the Beach Erosion Board and the Chief of Engineers.

Federal Law and Policy Pertaining to Navigation and Flood Control Projects--

The "Report on Survey of North Carolina Inland Ports and Waterways" contains the following information regarding Federal policy pertaining to navigation and flood control projects.

Under the 1950 Presidential Directive, all public works programs must be carefully screened to include only those projects which directly contribute to National defense or to civilian requirements essential in the changing international situation. This restriction has undoubtedly deferred construction or completion of many worthwhile projects in North Carolina.

No overall River and Harbor and Flood Control Authorization Act, otherwise known as an Omnibus Bill, has been passed by the Congress since May 17, 1950. It should be noted that these Omnibus Bills carry authorizations, not only for

individual investigations, but also for specific project construction. Concurrently, it has been increasingly difficult to obtain Bureau of the Budget approval and subsequent favorable action by the Congress as to funds unless these essentiality criteria are met. For instance, only one small North Carolina river and harbor appropriation item has received the Bureau's approval, $195,000 for salt water intrusion preventative measures at Fairfield, North Carolina, although further hearings before the Public Works Committee of the Congress may result in the inclusion of additional projects. (It is believed that the report should have indicated "the Appropriations Committees of the Congress" instead of "the Public Works Committee of the Congress" in the preceding sentence).

The Fairfield Drainage Sub-Project (of the Atlantic IntraCoastal Waterway Project) is the only North Carolina river and harbor item included in the recently passed Civil Works Appropriation Bill for the fiscal year 1955. It pertains to the installation of a pumping plant and other facilities for the prevention of salt water intrusion in the vicinity of Fairfield and Mattamuskeet Lake. The Federal cost was placed at $195,000 as compared to a 1947 estimate of $115,000 and is exclusive of about $12,000 in costs to be met locally. The proposed work was justified by the Corps of Engineers on the basis that the construction of the nearby IntraCoastal Waterway (presumably considered as directly contributing to national defense) has been responsible in some degree for increased and destructive salinity in local drainage canals; however, no actual waterway improvements are involved.

(The latest information available indicates that the 1950 Presidential Directive will not be strictly followed in connection with action toward obtaining appropriations for authorized projects.) Page X-9 of the "Report on North Carolina Inland Ports and Waterways" indicates the following projects for which it is anticipated that funds will be requested from the Congress:

Fiscal Year 1957--Wilmington Harbor
Fiscal Year 1958--Far Creek(Engelhard), Taylors Creek (Beaufort), and Back Sound to Lookout
Fiscal Year 1959--Manteo to Oregon Inlet, Masonboro Inlet, Beaufort Harbor, and Thoroughfare to Cedar Bay
Fiscal Year 1960--Rollinson Channel, Marshallberg Harbor, and Pamlico Sound to Rodanthe.

(It appears that most of the above projects would not meet the essentiality criteria of the 1950 Presidential Directive.)

The "Report on North Carolina Inland Ports and Waterways" contains the following information regarding Federal law pertaining to river and harbor improvements.

Recently curtailed appropriations have brought about a renewed interest in a provision of the River and Harbor Act of March 3, 1925. The pertinent extract from act reads as follows:

"Section II. That whenever local interests shall offer to advance funds for the prosecution of a work of river and harbor improvement duly adopted and authorized by law the Secretary of War may, in his discretion, receive such funds and expend the same in the immediate prosecution of such work. The Secretary of War is hereby authorized and directed to repay without interest, from appropriations which may be provided by Congress for river and harbor improvements, the moneys so contributed and expended."

Although in the past this provision was used frequently by local interests to advance construction on favored projects, recent developments and policies had, by fiscal year 1949, all but eliminated this procedure. Inquiries submitted to appropriate authorities indicate that the Corps of Engineers, the Secretary of the Army, and the Congress have, since World War II, frowned upon and persistently resisted any effort by local interests to proceed with an authorized project on the basis of local advancement of funds and subsequent reimbursement. In certain respects the procedure might be viewed as an infringement upon the appropriative function of the Congress. This is particularly true in recent years, since the Congress has modified its former practice of lump-sum appropriations delegating the allocation responsibility to the Chief of Engineers and now assigns funds to specific authorized projects. In other words, should a project be now undertaken and completed with funds advanced by local interests under the provisions of Section II, reimbursement of such funds could be made only through an appropriation for that specific project.

(The latest information available indicates that there has been no change in the situation indicated above pertaining to offers of local interest to advance funds for works of river and harbor improvement.)

Recommendations Pertaining to Navigation Improvements --The "Report on North Carolina Inland Ports and Waterways" contains the following recommendations regarding the need for various corrective and beneficial actions for the development and better use of North Carolina's inland waterways:

(1) Establishment of a Waterway Development Fund, under the administrative jurisdiction of the Department of Conservation and Development, with an annual operating budget in the order of $500,000.

(2) Provision of funds in the amount of $500,000 to accomplish the first-year program as follows:

(a) Initiation of dredging operations on the Federally authorized Manteo Bay to Oregon Inlet 12 to 14-foot Channel Project. Work to be confined to the inlet proper and to such limited reaches of the 24 miles of channel where the removal of localized shoaling would add materially to the present restricted controlling depth. Recommended allotment - $150,000.

(b) Initiation of work within Drum Inlet proper, with concurrence of the Chief of Engineers since this portion lacks Federal authorization, and removal of shoaling in the lower end of the existing approach channel-an authorized project. Recommended allotment-$100,000.

(c) Initiation of work on the Masonboro Inlet Channel Project exclusive of the provision of the seaward jetties and including any localized shoaling in Banks and Motte Channels. Recommended allotment-$100,000.

(d) Initiation of a program for the provision of small harbors of refuge at critical points along the several waterways, after field investigations are made to determine suitable locations where relatively limited dredging operations give promise of material benefits. Recommended allotment-$75,000.

(e) Assistance in the maintenance and deepening of the locally provided opening through the barrier just north of Carolina Beach, which connects Myrtle Sound and the ocean. Also removal of localized shoaling in the channel to that community. This is not a Federally authorized project; it is under study with a view to possible adoption. Recommended allotment - $25,000.

(f) Emergency dredging, contingencies, investigations, planning, and administration. Recommended allotment - $50,000.

The Department of Conservation and Development does not concur in the above recommendations for the following reasons.

a. As indicated on page X-9 of the "Report on North Carolina Inland Ports and Waterways", it is anticipated that funds to complete, or partially complete, the Manteo to Oregon Inlet Project will be requested from the Congress for work on the project during the Fiscal Year 1959. The funds required to complete the project, based upon the most recent estimate, amount to $1,104,800. It is not known whether the Chief of Engineers will request this amount for the purpose of completing the project or whether he will request a smaller amount for the purpose of effecting a partial completion of the project. It appears certain, however, that he will request sufficient funds to complete the project, or to complete one or more features of the project, because the costs of demobilization and remobilization of plant and equipment, if work on the project, or one or more features thereof, is suspended, will unnecessarily and unwisely increase the total costs of the project. If the General Assembly of 1955 or the General Assembly of 1957 or any subsequent General Assembly appropriates funds for work on this project or a sub-project thereof in order to enable the State of North Carolina to offer to advance funds for such work, with a view to advancing construction thereof upon determination of its favorableness with respect to other projects or sub-projects, authorized but awaiting appropriations, the amount appropriated by the General Assembly should be sufficient to complete the project or a sub-project or sub-projects thereof. In the case of a sub-project or sub-projects, the name or names thereof should be specified. Such action might commit a subsequent General Assembly to certain appropriative action. If the offer were made prior to a change in the situation, previously indicated in this chapter and pertaining to offers of local interests to advance funds for works of river and harbor improvement, the offer would probably be declined, and the funds appropriated would be revoked or used for other purposes or held awaiting a change in the situation referred to above. It appears that funds in connection with this project will not appropriately be a matter for consideration by the General Assembly of 1955.

b. The Drum Inlet Project was completed in 1940, as indicated previously in this chapter under "Projects Completed". The work consisted of dredging in Core Sound only. Dredging in Drum Inlet cannot be performed until after such dredging has been authorized by the Congress and funds therefor have been appropriated by the Congress or funds therefor have been offered by the State if and when the present policy pertaining to such offer has been changed. Several years will elapse before investigation pursuant to a Congressional resolation, report thereon by the Chief of Engineers, and authorization by the Congress subsequent to consideration of the report can be effected. It appears probable that the General Assembly of 1959 will be the first State legislative body which could be in position to take action enabling the State to offer to advance funds for the work. The Department of

Conservation and Development concurs in the statement in the "Report on Survey of North Carolina Inland Ports and Waterways", previously indicated in this chapter, that attempts to dredge new, or maintain old inlets, may be in direct opposition to intensive and usually unpredictable forces. It is believed that no dredging should occur in any inlet until such inlet has been stabilized by construction of jetties or until stabilization has been accomplished by another method.

c. The Department of Conservation and Development is of the opinion that no dredging in Masonboro Inlet should be performed until the inlet has been stabilized by construction of jetties or until stabilization has been accomplished by another method or until the State has been advised by the Chief of Engineers that dredging prior to stabilization is capable of being dealt with successfully.

d. The recommended initiation of a program for the provision of small harbors of refuge at critical points along the several waterways is not understood. The only harbor of refuge in North Carolina waters is the Cape Lookout Harbor of Refuge, information regarding which has been set forth previously in this chapter under "Projects Under Way--Light-Draft Vessels". Work on this harbor was done in 1917, presumably to provide shelter of sea-going commercial vessels in stormy weather and protection of naval ships from submarine attack. The harbor is not extensively used, and no information is available regarding any effort to obtain construction of the portion of the breakwater, 2,250 feet in length, required for completion of the authorized breakwater, 7,050 feet in length. If the indicated harbors of refuge are the six mooring basins at various locations along the waterway, indicated previously in this chapter under "Projects Under Way--Light-Draft Channels, Atlantic Intracoastal Waterway between Norfolk, Virginia, and Little River, South Carolina", the remarks in sub-paragraph a. immediately above, pertaining to an offer of funds for performance of construction of an authorized project with a view to advancing such construction, would appear to be applicable. If the indicated harbors of refuge are proposed basins in which light-draft vessels may obtain shelter and protection in stormy weather, several years will elapse before authorization of the congress for their construction could be obtained. Furthermore, even if present policy is changed to permit local interests to obtain earlier completion of authorized projects subsequent to offers to advance funds for construction thereof, it appears that other urgently needed projects would have a higher priority in connection with consideration of such action.

e. The Department of Conservation and Development is of the opinion that it would be inadvisable for the State to provide funds for the maintenance and deepening of the locally provided opening through the barrier just north of Carolina Beach, which connects Myrtle Sound and the ocean, and removal of localized shoaling in the channel to that community for the following reasons.

(1) The opening has not been approved by the Chief of Engineers or authorized by the Congress.

(2) The channel from Myrtle Sound to the community is not an authorized project.

(3) The State has no authority to participate in dredging in the opening or in the channel.

(4) Dredging in the opening should not be performed until the opening has been stabilized by construction of jetties or until stabilization has been accomplished by another method or until advice has been received from the Chief of Engineers that dredging prior to stabilization is capable of being dealt with successfully.

f. The Department of Conservation and Development is of the opinion that appropriation by the General Assembly of funds for emergency dredging and contingencies is inadvisable and that need for provision of such funds can be discharged through allocation by the Council of State from the Contingency and Emergency Fund. It is believed that investigations, planning, and administration, pertaining to waterway improvements can be accomplished by use of the funds made available biennially to the Division of Water Resources, Inlets and Coastal Waterways, Department of Conservation and Development. If and when funds are appropriated by the General Assembly for dredging, emergency or otherwise, or are allocated by the Council of State for emergency dredging, it is believed that the funds should be made available to the Corps of Engineers for performance of the dredging, and that such performance by the State through purchase or rental of or contracting for, dredging equipment is inadvisable and unreasonable.

Sources of Revenue to Effect Recommended Improvements - - The "Report on Survey of North Carolina Inland Ports and Waterways" sets forth sources of revenue for support of the recommended Waterway Development Fund and indicates general principles with which utilization of the Fund should be in accordance. It appears to be inadvisable to comment herein on the proposed sources of revenue to support the fund. One additional source which might be considered, if and when occasion therefor arises, is cooperation by local interests similar to the contribution of $12,000 in connection with the appropriation of $195,000 for installation of a pumping plant and other facilities for the prevention of salt water intrusion in the vicinity of Fairfield and Mattamuskeet Lake. The general principles with which utilization of the Fund, if and when established, should be in accordance are considered to be reasonable.

Improvement of Waterfront Appearances - - The "Report on Survey of North Carolina Inland Ports and Waterways" recommends that advice and technical assistance be provided to coastal communities on clean-up, rehabilitation and beautification programs of waterfront structures and areas in prospective tourist ports. The Department of Conservation and Development desires to be of every possible assistance to coastal communities in improving waterfront appearances. Such assistance, until State funds therefor have been provided, will be limited to advice and technical assistance regarding the use of funds which may be appropriated by coastal communities or expended by property owners whose civic pride might cause them to take action which will result in enhancement of their property values and improvement of the appearances of the areas in which they reside or are engaged in business.

Cooperation With Federal Agencies and Congressional Committees - - The "Report on Survey of North Carolina Inland Ports and Waterways" contains recommendations that present programs in cooperation with Federal agencies relative to domestic and industrial water supply, stream pollution, and beach erosion be continued, and that facilities be expanded, and present methods be coordinated, in connection with forcibly placing before officials of the Corps of Engineers, and the appropriate committees of the Congress, all necessary data and arguments in support of waterway and flood control projects, with a view to their early authorization and/or fund allocation. The Department of Conservation and Development will continue, and will endeavor to expand, when considered advisable, cooperative agree-

ments with the Geological Survey, United States Department of the Interior, covering measurements of stream flow, chemical analysis of surface waters, salt water intrustion studies, and collection of data pertaining to ground water; and will continue collaboration with the Corps of Engineers and the Beach Erosion, and the State Stream Sanitation Committee, in connection with beach erosion and abatement of stream pollution, respectively. No expansion of facilities or coordination of present methods in the immediate future to accomplish such cooperation and collaboration is considered to be necessary. The Department will take appropriate action to obtain the support of the National Rivers and Harbors Congress, the Chief of Engineers, and the North Carolina delegation in the Congress in obtaining authorizations of, and appropriations for, navigation improvements. It is believed that the views and recommendations of local interests should be obtained and presented at meetings of the National Rivers and Harbors Congress and hearings before the Commerce Committee of the Senate and Public Works Committee of the House of Representatives pertaining to authorization of projects, and at hearings of the Appropriations Committees of the Congress connected with appropriations for navigation improvements. Local interests should be advised that their presence at such meetings and hearings, together with the North Carolina delegation in the Congress and representatives of the Board of Conservation and Development and of the Department of Conservation and Development, will be of great assistance in obtaining the desired authorizations and appropriations, particularly the later.

Action Toward Greater Use of Inland Ports and Waterways - - It is certain that greater use can be made of our inland ports and waterways. The following information is extracted from Chapter XI, Water Transportation, Report on Survey of North Carolina Inland Ports and Waterways, prepared for the North Carolina State Department of Conservation and Development by Parsons, Brinchkerhoff, Hall and Macdonald, Engineers, New York, N. Y., 1954.

Eastern North Carolina, and its hinterlands, produce or consume millions of tons of commodities suitable for water transportation, which is a cheaper method of transport than its competitive forms in most cases. Barge shipments of bulk cargo on the inland waterways effect great economies. Bulk cargo includes gasoline, oil, grains, coal, sand, gravel, ore, sulphur, scrap iron, oyster shells, and chemicals.

If handled in slings or heavy single units, other commodities approach bulk cargo characteristics with respect to shipping costs as influenced by terminal operations. This class of commodities includes pulpwood, lumber, heavy pipe, tobacco in hogsheads, baled cotton, steel plate, structural shapes, and crates a barrels of uniform shape and weight. Any departure from homogeneity in the cargo handled at a particular mooring or on a single barge is reflected in higher, overall shipping costs. Highest costs result from a mixed cargo of packaged freight of varying size and weight. Such cargo not only increases terminal handling difficulties and labor charges but also adversely affect stowing efficiency in the vessel.

Differences between land and water costs and rates have created economic barriers to expansion in the near future of general cargo or packaged freight movements which involve relatively short hauls to or from Eastern North Carolina shallow-draft ports. Barge line officials who are successfully transporting such cargoes are of the opinion that the development of this type of traffic must await further industrial expansion and the increased tonnage which such expansion will produce in the Coastal Plain and its immediate hinterlands. Some of these officials

believe that increased channel depths, with full 12 feet or more assured at all times, would greatly encourage water-borne commerce of all types. However, the vast Ohio-Mississippi system, which carries enormous water traffic, has a controlling depth in most places of 9 feet. Any build-up of industrial and other tonnage-producting activities in the coastal areas of North Carolina will bring the day that much closer when water-borne movements of other than the more favorable commodities, usually carried as bulk cargo, may be profitably developed.

It appears from the information and conclusions set forth in the report on survey of North Carolina inland ports and waterways that, in order to make greater use of these ports and waterways, local interests must take the following action:

a. Effect the establishment in the Coastal Plain of industries which will increase the tonnages handled at the ports and on the waterways; and

b. Secure the support of, and required action by, the North Carolina delegation in the Congress of the United States in obtaining Federal appropriations for navigation projects which have been authorized by the Congress and in effecting the authorization of navigation projects which have been, or will be, recommended by the Chief of Engineers.

The authorized projects which require appropriations for initiation or completion are as follows:

Construction of a channel 12 feet deep and 90 feet wide in New River between the Intracoastal Waterway and the Atlantic Railroad Bridge at Jacksonville, 21 miles, and a basin at Jacksonville;
Deepening the channels from Oregon Inlet to Manteo and from Roanoke Sound to wharves in Mill Creek near Wanchese, and construction of basins at Manteo and in Mill Creek near Wanchese;
Deepening the channel from Pamlico Sound to Engelhard and the basin at Engelhard;
Deepening the channel from Deep Bay to Swan Quarter Bay, the Swan Quarter Canal from Swan Quarter Bay to the Town of Swan Quarter, and the basin at the town;
Deepening the channel from Pamlico Sound to the Town of Hatteras and the basin at the town;
Deepening the channel between Thoroughfare Bay and Cedar Bay;
Construction of a channel from Core Sound to the Town of Sealevel and a basin at the town;
Construction of a channel from The Straits to the Town of Marshallberg and a basin at the town;
Increasing the width and length of the basin in front of Beaufort and deepening the channel in Taylors Creek; and
Construction of a channel from Pamlico Sound to the Town of Rodanthe and a basin at the town.

The proposed projects which require authorization are as follows:

A side channel to Elizabeth City via Albemarle Sound and Pasquotank River so that small tankers and freighters sailing the Intracoastal Waterway could make deliveries to Elizabeth City;
A channel from the Intracoastal Waterway in Bogue Sound into Peltier Creek;

A side channel and boat basin, and modification of existing breakwaters, in Belhaven Harbor;
A deeper channel from Hatteras Inlet to the Town of Hatteras, and breakwaters for the entrance to the harbor at the town;
Construction of a breakwater and deepening the harbor at the Town of Oriental;
Enlargement of the turning basin at Morehead City Harbor and increased depths in the basin and in the present 30-foot deep channel;
Deepening the ocean-bar channel at the mouth of the Cape Fear River, the river channel from the mouth to Wilmington, and the anchorage basin at Wilmington; and
Deepening the channel above Castle Street in Wilmington to Hilton Bridge over the Northeast (Cape Fear) River.

It may be necessary, in connection with appropriations for, and authorizations of, some of the projects indicated above to effect the establishment of additional industries in order to increase the tonnages handled at the ports and on the waterways, so that the benefits to navigation may be equal to or greater than the costs of the work required to accomplish construction of the projects. In such cases, local interests should encourage and take positive action to accomplish the establishment of the industries. The construction of the greater part of the projects will benefit commercial fishing, and increase thereof will be highly valuable to the economy of the people of Eastern North Carolina.

The development of ports and waterways is a matter of great concern to many states in the United States, which are faced with problems pertaining to establishment of new industries which will result in additional water transportation, and to obtaining authorizations of, and appropriations for, navigation improvements. Local interests in many of those states, in cooperation with their State governments and their delegations in the Congress, have been successful in securing needed measures to increase water transportation. The people of North Carolina should make every possible effort to be similarly successful.

Purposes, Methods, and Effects of Flood Control - - Flood control is related to high water flows and consists of holding rivers within their banks by reducing the peak discharges, or of limiting areas of flooding by the use of protective works. The primary purposes of flood control are to reduce the damage to property and to reduce danger and inconvenience to the people located within the overflow limits of rivers.

Flood control is usually accomplished by the use of flood-control dams and retarding reservoirs, or by levees and floodwalls, or a combination of both of these methods. The use of levees and floodwalls may also include channel improvements, such as realignment and bank revetment, to make the protective works effective. In planning flood control reservoirs, consideration is given to providing for recreation and for low flow control for pollution abatement.

Flood control projects have been established primarily to avert disaster from flood waters. There are, however, many resulting contingent benefits. Although not fully realized, conservation of flood water has a far-reaching effect, not only in minimizing water shortages for industrial requirements but in improving water quality. By stream flow control, the effect of depreciation of water quality by industrial and sanitary wastes is reduced in accordance with the degree of regulation. One of the most direct benefits resulting from such regulation is the prevention of salt water intrusion into tidal rivers. It is a well known fact that salt water penetration into many fresh water streams results from insufficient river flows. During the severe droughts of 1930 and 1931, the salt content of the Delaware River at Chester, Pennsylvania, rose to 1860 parts per million. This location is approximately 20 miles upstream from the mouth of the river. Normally, the salt content of the river in this area is less than 25 parts per million. Such conditions are reflected directly in the cost of treatment of the supply.

The damages occasioned by floods are notable on account of their sudden and serious character. Floods destroy property and life, and losses are direct and measurable. Much can be done toward alleviation and prevention of these conditions by intelligent engineering works if supported by enlightened public opinion. The great increase in these losses with the development and growth of the State is creating a constant demand for such betterments. Unfortunately, it generally requires a specially disastrous flood to arouse the public and make it realize the need and value of flood protection.

Flood control is a comprehensive problem involving social, political, and economic interests as well as the basic factors of hydrological studies and engineering works. Also, flood control is only one phase of the development and control of our water resources; related phases are navigation, water supply, irrigation, and ground water storage. In flood-control planning, proper consideration should be given to all of the interests involved.

Fundamentally, flood control means regulating the run-off from excessive rainfall on a watershed so that the flow can be carried within the banks of the stream. There are two general classifications of all flood-control measures. In the first class are those projects which hasten the flow of water from the watershed, such as channel improvement, bank protection, and levee construction. In the second class are those projects which retard the flow of flood waters by proper land-use practices and the construction of storage or detention basins. On water sheds such as those of the Neuse, Cape Fear, Tar, and Yadkin Rivers, a combination

of these control methods might be effectively employed.

Responsibility for Flood Control - - The River and Harbor Act of 1927, the Flood Control Act of 1936, and subsequent flood-control legislation have authorized investigation by the Corps of Engineers, Department of the Army, of water resource developments for flood control and other purposes in addition to navigation. The procedures for flood control investigations by the Corps of Engineers and reports thereon are similar to those indicated for navigation in the preceding chapter. Many flood control projects in North Carolina have been recommended by the Corps of Engineers as a result of their investigations, and the Congress have authorized some of them for construction. There are no authorized Corps of Engineers projects which include power development in North Carolina. A system of flood-control reservoirs in the upper Yadkin River Basin is authorized. The large John H. Kerr Reservoir in the Roanoke River Basin, created by the construction of the John H. Kerr Dam near Clarksville, Virginia, includes an area of approximately 25 square miles, located in Granville, Vance and Warren Counties, North Carolina. The Philpott Reservoir in the Roanoke River Basin is located entirely within the State of Virginia. Its benefits extend, however, into North Carolina.

Flood Control Projects, Constructed, Authorized, and Under Investigation - Several small local flood protection projects have been constructed or authorized. The completed projects include the clearing and snagging of the natural channel of Tar River between Tarboro and Rocky Mount, and a cut-off channel, with a check dam at the bottom thereof, across two adjoining bends in Neuse River near Goldsboro. The authorized projects include the Pasquotank River Flood Control Project, the Moores Ferry Reservoir, and the reservoirs in the upper Yadkin River Basin near Wilkesboro and North Wilkesboro, North Carolina. The flood control preliminary examinations and surveys under way include the following:

a. Reservoir near Smith Mountain, Virginia.
b. Reservoir near South Boston, Virginia.
c. Flood control and drainage improvements on Perquimans River.
d. Lowering flood stages and improving drainage, Filberts Creek at Edenton.
e. Flood control and major drainage for farm lands in the upper Pungo River Basin.
f. Flood control and drainage improvements in the Core Creek Watershed, Neuse River Basin.
g. Flood control improvements for farm lands along Neuse River between Smithfield and Wayne County line.
h. Improvements to reduce floods, facilitate drainage, and permit higher utilization of land and water resources, Neuse River and Tributaries.
i. Improvements for flood control drainage and other purposes in the entire Cape Fear River Basin.
j. Improvements for flood control and allied purposes on the French Broad River and Tributaries above Douglas Dam in Tennessee and North Carolina.
k. Flood control and major drainage improvements, Chowan River Basin.

Pasquotank River Flood Control Project - - Pasquotank River extends from the northeastern part of Albemarle Sound near Elizabeth City northwest into Dismal Swamp near the Virginia-North Carolina State line. The area included in the authorized project is adjacent to that portion of the river in Newland Township, Pasquotank County, northwest of Elizabeth City, between points about 38 and 45 miles above Albemarle Sound.

The project provides for flood control by construction of a low dike and appurtenant outlet structures along the edge of the Dismal Swamp between Federal Highway 158 , about 3.6 miles northeastward and eastward to within about 700 feet of Pasquotank River.

The 1952 estimate of cost for the project is $125,000. The average annual flood control benefits that the dike would provide are estimated at $10,900. Protection against the highest flood of record would prevent damage from flooding and impaired drainage estimated at $60,000. In addition to the evaluated benefits substantial invaluable and intangible benefits would accrue.

Moores Ferry Reservoir - - This reservoir would be in Grayson County, Virginia, and Allegheny County, North Carolina, near Galax, Virginia, 214 miles above the confluence of the New and Gauley River, and 311 miles above the mouth of the Kanawha River. The project provides for a concrete gravity dam on New River for flood control from an area of 1,130 square miles. The structure would have a maximum height above stream bed of 172 feet, a total length of 1,320 feet, an uncontrolled overflow spillway, and outlet works through the dam. A conservation pool at 2,275 feet elevation above mean sea level would have a storage capacity of 60,000 acre-feet and an area of 2,000 acres. Above this elevation, to 2,357 feet, a storage capacity of 361,000 acre-feet would be reserved for temporary storage of flood flows.

The reservoir is designed to operate as a unit of an authorized coordinated reservoir system for flood protection in the valleys of New, Kanawha, and Ohio Rivers. It is estimated that the reservoir would prevent about $1,000,000 in damages below the dam site and above Bluestone Reservoir, and about $36,000,000 in the New and Kanawha River Valleys, in the event of operation during the project flood. To the extent consistent with flood control purposes, the reservoir would be developed for recreational activities, for provision of increased low flows for pollution abatement and water supply, and for the beneficial use of agricultural lands, forests, and fish and wildlife resources. In the event of Congressional authorization for use as a multi-purpose project, the storage capacity would be increased and utilized for power generation and regulation of flows to increase the power output of downstream developments.

The estimated cost of the project as authorized for flood control is $23,400,000; there are no non-federal costs. No funds have been appropriated for construction.

Perquimans River - - The completion of an investigation by the District Engineer, Wilmington District, Corps of Engineers, of the feasibility of providing flood control and drainage improvements on Perquimans River is indefinite.

Filberts Creek - - The completion of an investigation of the desire of local interests for improvement of Filberts Creek at Edenton in order to lower flood stages and improve drainage is indefinite.

Pantego and Cucklers Creeks - - As of January 1, 1953, the investigation to determine the advisability of providing flood control and major drainage for farm lands in the upper Pungo River Basin, by either enlarging existing trunk canals or excavating alternative intercepting canals, was scheduled for completion during the Fiscal Year 1953.

Waccamaw River, North Carolina and South Carolina - - A survey-review report on an investigation of the advisability of improvements for flood control, by channel clearing, rectification, and diversion, in the Waccamaw River Basin, North Carolina and South Carolina, was submitted by the Division Engineer, South Atlantic Division, Corps of Engineers to higher authority during the Fiscal Year 1952. As of January 1, 1953, the project had not been authorized by the Congress.

Santee River System, North Carolina and South Carolina - - As of January 1, 1953, the investigation by the District Engineer, Charleston District, Corps of Engineers, of improvements for navigation, flood control, and other beneficial water uses in the Santee River Basin, involving the Broad and Catawba Rivers and tributaries in North Carolina, was about 50 per cent complete, and the date of the completion of the District Engineer's report thereon was indefinite.

Further information regarding flood control projects and investigations may be found in subsequent volumes covering inventories of water resources of the Neuse, Cape Fear, Tar-Pamlico, Yadkin, Roanoke, and Chowan River Basins.

Performance of Emergency Work - - Emergency flood control work has been performed by the Corps of Engineers in North Carolina as follows:

Dikes in Bladen County along Cape Fear River - - In May 19 47, filling the breaks caused by the September 1945 flood in about five miles of dike on the left bank of the Cape Fear River near Lock and Dam No. 1 was completed at a cost of $36,500. These dikes were constructed by local interests about 1910; subsequent maintenance and general extension has been performed by the North Carolina State Highway and Public Works Commission.

Trent River (Trenton to Jones - Lenoir County Line) - - During the Fiscal Year 1952, Federal allotment of $50,000 and contribution by local interests in the amount of $15,000 were received by the District Engineer, Wilmington District, for clearing and snagging Trent River between mile 38 and mile 75.5 above the mouth at New Bern. The project was about 25 per cent complete on June 30, 1952, and about $19,500 had been expended on the upper 9.2 miles of the project. As of January 1, 1953, the project was scheduled for completion during the Fiscal Year 1953, and it was anticipated that, when completed, the project would substantially lower flood stages and decrease the time of flooding above and along the improved reach, thereby providing flood control and improving drainage on about 5,000 acres of land.

New River (Onslow County) - - During the Fiscal Year 1950, about 16.5 miles of New River were cleared and snagged for flood control, between miles 29.5 and 46.0, beginning about 10 miles above Jacksonville, at a cost of about $33,900. The improvement substantially lowered flood stages and decreased the time of flooding, decreasing flood damage on about 1,000 acres of farm land and improving drainage on a much larger area.

Beach Erosion Studies in North Carolina--In years past, the need for detailed and accurate information on beach erosion had not been fully realized by beach property owners and others directly concerned. In 1924, the North Carolina Fisheries Commission made an unsuccessful attempt to open and maintain an artificial inlet in the barrier beach near Rodanthe. This costly failure and the rapid growth of seashore resorts about the same time brought a realization of the need of beach erosion studies to the attention of interested citizens of the State of North Carolina. Accordingly, in 1927, the North Carolina Department of Conservation and Development began limited studies of beach erosion in the State. These studies were later expanded until they covered primarily the areas of highest property value. Investigations were continued until 1941, when the exigencies of the war forced their abandonment. The studies, which were, and are being, prosecuted in cooperation with the United States Beach Erosion Board and the Corps of Engineers, were resumed in the summer of 1954.

There is no ready way of predicting when it will be necessary to build protective works to save valuable beach property. Consequently, beach communities may be suddenly confronted with an erosion problem for the solution of which no data are available. Since protective works are expensive, they also may have a financial problem suddenly thrust upon them. Local judgment generally determines the method to be used in stabilizing the beach. Such determination has resulted in wide differences in the character, planning, and design of protective works. Some of these protective works have been effective, others have been useless, and still others have done more harm than good. It is believed that, by proper evaluation of the factors involved, data collected will show the trend, rate, and manner of erosion. Interested parties may then predict with some success, in a long-term sense, when and where protective works are needed. The type of works that will adequately solve the problem in the most economical way may then be planned.

History of Inlets and Beaches at Various Places in North Carolina--Oregon Inlet has the dubious distinction of being the most changeable inlet in the United States. The Coast Guard finds it necessary to shift the buoys after each storm, in order to mark the best water in the entrance channel, and the changes are so frequent that no attempt is made to chart the channel buoys. The depths in this channel have varied from 5 to 17 feet in past years. Several interesting changes have been noted in past years: (1) the entrance channel has migrated south more than one mile, and (2) the inlet has widened from less than $\frac{1}{2}$ mile in 1848 to 3/4 mile in 1912, and then $1\frac{1}{4}$ miles in 1942, the date of the last survey. The 1912 survey shows a characteristic tip at the end of the north spit which is now lost. The barrier island to the south of Oregon Inlet has migrated bodily to the south about one mile in 100 years.

The history of Cape Hatteras extends over a period of 100 years. Former surveys show an accretion to the beach line to the north of Cape Hatteras of more than $\frac{1}{4}$ mile from 1850 to 1909, and a loss to the original shoreline by the date of a survey in 1948. The cape itself built out about one mile from 1850 to 1927, and has receded about one-half that distance from 1927 to 1953. Some ten miles to the southwest of the Cape is Hatteras Inlet which, like Oregon Inlet, has progressively widened from $\frac{1}{2}$ mile in 1850 to about one mile in 1953, and was widest in 1909. The inlet itself has moved southwestward along the general trend of the coast.

The history of Cape Lookout and vicinity extends over a period of more than 100 years. The Cape itself is remarkably stable, having moved 3/8 miles to the eastward and retaining its characteristic shape throughout the years. It is interesting to note that the shoreline of both the 1850 and 1905 surveys was about the same, and that the 1924 and 1946 surveys agreed. Consequently, the entire movement occurred apparently between 1905 and 1924. This agreement between surveys of changes is also true of the beach to the north of the Cape.

Ocracoke Inlet, unlike Oregon and Hatteras Inlets, both of which widened throughout the years, has decreased in size from 1½ miles to a little more than ½ mile, practically all of this change having occurred on the north spit. A survey made in 1909 in this vicinity showed a tremendous loss of material from the date of the earlier survey, the spit narrowing at that time to a mere 1/8 mile in width. Since 1909, this spit has not only regained its former size but also has extended southwestward about 1¼ miles. The island at the entrance decreased in size from ½ mile in diameter in 1850 to less than 1/8 mile in 1909, and now appears as two sandmounds in the entrance. The westerly spit has more or less retained its position and shape throughout the years.

The history of Cape Fear and vicinity involves some 100 years of shoreline changes. At the extreme north there has been a loss of about ¼ mile of beach, and a tremendous gain as far south as the inlet opposite the south end of the jetty. The spit near the jetty has widened from a few hundred yards to more than one-half mile. This jetty, constructed between 1870 and 1880, must have had a tremendous influence on the distribution of material along this section of the coast. To the south of the inlet the beach has receded an average of ¼ mile, and the Cape itself has migrated northward about ½ mile. Swinging around the Cape to the east entrance of the river, a gain of beach of about ¼ mile has occurred. As in several previous examples of inlets to the north, the western spit of the entrance to the Cape Fear River has moved but very little during the past 100 years.

Description of the Coast Line of North Carolina--Most of the coast line of North Carolina is defined by a barrier beach facing the ocean and separated from the mainland by lagoons or sounds. This coast line is not continuous but consists of a series of lowlying islands separated by tidal inlets which form the connection between sound waters and the ocean. This barrier beach is composed principally of sand and varies in width from a few hundred feet to several miles. For most of the length, there exist sand dunes immediately to the rear of the beach proper, averaging 10 to 20 feet in height. A few large dunes rise to 75 feet or more in height, principally in the Nags Head area.

The precise manner in which this barrier beach originated is not known. One of the more popular theories states that this reef was built on the submarine floor where the currents have deposited materials brought down by streams. Here the deposit was subjected to the mutual reaction of breakers and under-tow, and finally a great reef was heaped up parallel to the general trend of the shore line. Another theory advanced is that, when waves roll in on a shelving shore, energy is expended on the bottom. There is a zone of maximum action. This zone is seaward in storms. Here the bottom is deepended and coarse particles are moved landward, forming a shoal and, in time, a bar enclosing a lagoon. In the meantime, finer particles are moved seaward where they are distributed in moderate thickness over a considerable area. Still

another theory assumes that the sounds are sunken river valleys and that the offshore bar was formed from "shore drift" which is moved parallel to the shore by longshore currents. The most violent agitation of the water is along the line of breakers, and the shore drift, depending on agitation for its transportation, follows the line of the breakers instead of the water margin.

This theory has the offshore bar depending on shore drift for its existence. If the supply of shore drift is cut off, the structure is demolished by the waves which form it. The smaller connecting sounds were low places between the divides of the river estuaries, which were partially submerged and later enlarged by erosion.

From the Virginia line to Beaufort Inlet, the water area behind the barrier consists of large shallow sounds and connecting waterways and estuaries. (The maximum depth of the sounds is about 20 feet while the average is probably about 8 feet.) From Beaufort Inlet southward, the lagoons and connecting waterways are quite shallow and narrow. In many places, they are little more than salt marshes.

The inner beaches on the mainland are narrow and sandy, and frequently consist of swampy lands that extend below the water lines. Adjacent lands are generally low, sometimes marshy, and frequently wooded. The population is sparse, particularly on and near the barrier beach. The fish of these waters and the migratory game birds are important elements in local economic life, both as a food supply and as an attraction to sportsmen.

Within the area lie points of considerable historical interest, both to the State of North Carolina and to the Nation as a whole. In the Nags Head area are the sand dunes known as "Kill Devil Hills". It is from one of these dunes that the Wright Brothers took off on the first airplane flight which marked the beginning of heavier-than-air transportation. One of these dunes has had its sand anchored and a monument erected on its top in memory of the Wright Brothers. Fort Raleigh, on the north end of Roanoke Island, marks the site of the defense of the settlers of the Sir Walter Raleigh Expedition. It is here that Virginia Dare, the first white child of English colonists in America, was born. At Cape Hatteras stands the tallest brick lighthouse in America, which for nearly 100 years has stood guard over dreaded Diamond Shoals, extending 20 miles to the east. These shoals are known the world over as "The Graveyard of the Atlantic". Fort Macon, a State park, is located west of Beaufort Inlet. This fort was built before the Civil War for defense against marauding pirates who roamed these shores at that time. The fort is still well preserved and remains a masterpiece in brick architecture and construction. On the eastern spit at the mouth of the Cape Fear River, a mound of earth once stood which was called Fort Fisher. This fort figured prominently in the defense of Wilmington during the Civil War. The fort withstood the bombardment of practically the entire Federal fleet and was finally subdued only by troops from the landward side.

Methods and Purposes of Collecting Beach Erosion Data--In each area studied during the investigations referred to above, a base line was established for the entire length of the area, sufficiently landward of the high water line to be safe from immediate erosion and, in some instances, located where the points would be fairly permanent. The base line was monumented and referenced to the U. S. Coast and Geodetic Survey, U. S. Geological Survey, and Corps of Engineers monuments located in the vicinity. This base line was tied to permanent stations, and the correct location and elevation of all monuments were

established. Accuracy is that of third-order traverse with third-order leveling. In each area, such control forms the reference from which all maps and offset profiles are made.

Beach and offshore profile lines were established perpendicular to the shore at selected locations in each area. These profiles extend from the base line to at least 1500 feet seaward in the surveys of 1940 and those prior thereto. In the 1954 surveys, the profiles were run only to the zero mean sea level or low tide. These profiles were measured by leveling to wading depth, and then extended to their seaward limit by soundings from samll boats. Experience proved that these profiles could be most satisfactorily extended seaward by having the boatman move slowly seaward on a line of shore flags while the leadsman threw the sounding line. The sounding line was "cut in" at the instant it was vertical by a transit on a shore station.

These profiles yield the bulk of the data necessary to an understanding of the changes that take place in beach erosion surveys. Superposition of profiles for different times at one station yield information as to changes in dunes, cliffs, beach slope, bottom slopes, water lines, and depth curves. Such profiles are also the control required for measurement of offshore velocities.

Topographic maps were made of inlets and beach areas by use of stadia methods, using plane table and alidade. This type of map is rapidly made in the field, and accuracy is secured by using base line stations as a control.

Comparison of inlet maps with those of former years reveals migratory trends of inlets and changes in the shape of the lips of the inlets.

Littoral currents were measured by use of subsurface floats. These floats were of the vaned type and of such length that they measured velocities near the bottom. Measurements were made by releasing floats in sequence along the profile, generally at definite intervals of 350 to 400 feet. The position of the floats was then established at definite intervals by intersection readings from shore transit stations. The readings were continued until the group of floats had traveled about 2000 feet. They were then picked up, replaced on the profile, and the process repeated until it had covered a complete tidal cycle.

Littoral current records are useful in analyzing magnitudes, directions, and reversals of currents in the area during the tidal cycle. From such analysis, an approximation of the direction and intensity of littoral drift may be determined.

Longshore currents were measured by use of ordinary laundry blueing. The blueing was released in the water, and the colored cloud was followed until dilution made further observation impossible. The rate of travel of the cloud parallel to the shore was measured by an observer on shore equipped with a stop watch. These measurements were made in pairs, one just outside of the plunge point and the other near the limit of uprush. Such pairs of measurements were made at definite intervals until they had covered a complete tidal cycle.

Studies made by the U. S. Beach Erosion Board indicate that about 80 per cent of littoral drift occurs shoreward from the first breaking point of the waves. Therefore, longshore-current measurements are of great importance

in the determination of littoral drift. Waves which approach the shore obliquely set up a swift current just outside the plunge point. In their uprush, these waves make a long sweep along the shore with velocities sufficiently high to transport considerable quantities of sand. While the cloud measurements neglect the shoreward and seaward components, they give the component of velocity parallel to the shore. This component is the velocity component, which is indicative of the existence and direction of littoral drift.

Inlet investigations included measurements of the cross section of the inlet gorge and velocity measurements at this cross-section. The cross-section of the gorge was determined by soundings. Measurements of velocities were accomplished by anchoring small boats on the cross-section line and using current meters from them in the same manner as in stream gaging. These measurements, extending through a tidal cycle, permitted the computation of the total tidal flow through the inlet.

Inlet investigations are important in those areas devoted to commercial fishing. Inlets allow migratory species of fish to enter the sounds and furnish the necessary salinity in sounds for the maintenance of salt water fish and the growth of shellfish, such as oysters, clams, and scallops. A decrease in the tidal flow through an inlet will result in a salinity change in the adjacent sound, which will have a very deleterious effect on shellfish. Therefore, arrangements should be made to keep informed as to the tendency of such inlets to close or maintain their rate of flow.

Sand samples were collected on selected profiles at points about halfway up the foreshore. These samples were analyzed in the laboratory for grain size and shell content.

These sand analyses were made in the hope that a relationship could be found between the type of sand and the slope and hardness of the beach. Up to this time, the characteristics of the sand that will determine this relationship have not been determined.

Historical investigation of maps reveal changes which have taken place in shore lines. A superposition of these shore lines of different dates furnishes a picture of progressive changes over a considerable period of time. Such comparisons are a guide as to the trend of changes which may be expected to continue.

Beach Erosion in the Nags Head Area--From a study of old maps and a comparison of profiles made during the study, a general recession of the shore line is indicated in the Nags Hear Area. However, this recession is going on at a very slow rate. A number of profiles were measured from the Nags Head settlement westward over the dunes to the sound. A study of these profiles indicate that these large dune-ridges and the sound shore-line are moving westward. Statements from natives of long residence in the area also lead one to believe this to be true. Since the sand of this area has an average diameter of about 0.25 millimeter, it is easily moved by both wind and waves. Therefore, it would appear that, as the ocean side of these banks is slowly eroded, the sound side is showing an accretion due to the transportation of sand by wind as well as wave action. The net effect is a slow, landward movement of the whole barrier, with assurance that the barrier will exist for many years to come.

This retreat of the barrier can be retarded by dune-ridges of sand collected by sand fences. These sand fences are particularly effective as dune builders in those areas where dry sand is moved by wind action. However, they will not collect sand in the tidal flats where the sand is alternately exposed and covered by water during the rise and fall of the tide. This observation is borne out in the Nags Head area by the fact that at Kitty Hawk and Nags Head, where there is considerable dry blowing sand, dunes have been built by fences atop each other to a height of fifteen feet, while in the flats at Oregon Inlet the fences still stand as bare as the day they were built. After these dunes are artificially formed, they should be stabilized by grass planting. Many ridges in this area have been so stabilized by gathering grass from nearby marshes and planting it in clumps about a foot apart over the whole area of the dune ridge.

Observation has shown that the beaches in this area suffer most severe erosion from storm-driven waves and wind when they approach the shore from the northeast. As a consequence, a net southward drift of sand due to wave and wind action is to be expected. The southward migration of inlets and the presence of southward-trailing spits, such as that at Cape Hatteras, also confirm the existence of southward drift. It is evident that the current measurements that were made are not indicative of littoral drift in this area. Since many breaches in this beach show early closures, the littoral drift must be quite large. More conclusive evidence of the amount of littoral drift could be obtained by making determinations of sand in suspension during different conditions of weather.

The desirability of having additional inlets in this area is of great importance to the fishing industry. Inlets increase the salinity for the propagation of shellfish and also permit the entrance of great numbers of marketable fish, such as shad and herring. The dredging of an inlet is expensive, and, unless a deep gorge is cut, it is likely that the cut would close almost immediately as it did at New Inlet in 1924. However, there are numerous low spots in this area that are overtopped by moderately high tides. It would, therefore, seem possible to encourage the opening of an inlet by bulldozing the sand down near to the high water line and waiting for a relatively high storm-tide to flow across the low spot and thereby scour out a gorge to form an inlet. Such an inlet would most certainly have to be protected against littoral drift being deposited at the mouth and causing it to close.

Erosion at Wrightsville Beach--The erratic manner in which the south shores of Moore and Masonboro Inlets change is indicative of northward littoral drift at Wrightsville Beach. However, these inlets remain open, which would indicate there is at most a very small volume of material being moved at this beach. The slight migration of both inlets in so long a period of time is also inconclusive as to direction and volume of littoral drift. The float measurements also indicate weak currents, incapable of moving any considerable volume of sand. The groins constructed in 1939 would also tend to reduce littoral drift. In view of these considerations, one is led to the conclusion that the amount and direction of littoral drift at Wrightsville Beach is inconclusive from the data collected up to this time.

Evidently, the groin system and artificial fill have stabilized the Wrightsville Beach shore line except for the southern end. At this end of the island, erosion has continued, and the two southerly groins have been flanked. The profiles indicate that the offshore contours have continued to recede even

with the placement of artificial fill in 1939. It would appear that the Town of Wrightsville Beach must continue to repair the existing groins and periodically replace lost fill if a satisfactory beach is to be maintained. The closure of Moore Inlet would probably reduce the frequency and volume of artificial fill that would have to be supplied to the beach, and would provide space for almost unlimited expansion of this resort in a northerly direction. If this inlet were closed, it would be necessary to set new buildings back so that they would be safe from erosive action, which may be expected to supply new material to the area of the present groin system. Apparently, the main channel at Masonboro Inlet is continually pushing against the south shore of the island and causing the flanking of the groins in that area. This erosion could be effectively stopped by the building of a revetment around the south end of the inland.

Erosion at Carolina Beach and Fort Fisher--The current measurements made in this area are inconclusive as to direction of littoral drift. However, shoals off Cape Fear, the higher beach north of the intake of the Dow Company at Kure Beach, and the good beach north of the Coquina Rocks at Fort Fisher with erosion south thereof would indicate a predominance of littoral drift to the south. The profiles for Carolina Beach indicate that the shore line is in the process of slow recession while the offshore bottom is losing large quantities of material. This loss of material has resulted in considerable steepening of the offshore bottom.

A new inlet was cut from Myrtle Sound to the ocean at the northern extension of Carolina Beach. The construction was completed September 3, 1952. At the time the construction was performed, it was recognized that the inlet would likely have detrimental as well as beneficial effects.

The beneficial effects include the provision of an outlet for pleasure craft and commercial fishing vessels, increased salinity of Myrtle Sound, and decreased pollution in the sound. Beneficial results have already been realized to some extent, but it is too early to determine the extent and permanence of those benefits.

One of the anticipated damages was shoaling at the confluence of the inlet and the Intracoastal Waterway. Such shoaling could result from erosion of the inlet channel and/or from littoral drift entering the inlet. Since recent shoaling in the Waterway has been at a rate only one-forth as great as the earlier shoaling, it is possible that shoaling in the Waterway has resulted mainly from erosion of the inlet channel.

Another major detrimental effect, that it appeared might result from the provision of the inlet, was erosion to the south, including Carolina Beach. Available data indicate that littoral drift from the north predominates. If such indication is correct, the inlet would tend to increase beach erosion at Carolina Beach. As yet, there has been no increased erosion; in fact, local interests state that, in some places along Carolina Beach, substantial accretion occurred during the winter of 1953 - 1954. The effect of the inlet on erosion will be slow-acting, and it will probably require many years to show the net result.

The recession of the shore line at Fort Fisher is proceeding at a rapid rate, while the bottom at the southern end has experienced some accretion. Erosion in this area has been so severe that the mounds which were of

of primary historic interest at Fort Fisher have now entirely disappeared. In 1931, the Beach Erosion Board recommended a bulkhead to preserve the mounds and a groin system to arrest what was then a rapid recession of the shore line. Since the erosion is continuing, a groin system could still be built to arrest the recession of the shore line and a possible break-through to the Cape Fear River at this point.

General Summary of Beach Erosion in North Carolina--The barrier beaches in North Carolina are composed generally of sand, the median diameter of which averages about 0.25 mm. Sand of this size is easily moved by natural forces, such as wind, waves, and littoral currents. Since there are no headlands to form additional material, the effect of natural forces is to redistribute the material on the beaches. The variation in rate of supply and loss at any one point causes advance or recession of the shore line as indicated by the profiles for that point. Over all of the areas studied, the net general effect has been a retreat of the barrier as a whole. This retreat of the barrier is probably due to movement of the sand across the barrier by wind and waves and to losses of material which go to form the shoals at several points offshore. The retreat of the barrier is expected to continue, and costly buildings should not be erected near the ocean unless the owner is prepared to meet the cost of beach stabilization. However, the area between Kitty Hawk and Nags Head has a long-time history of accretion, and such accretion would naturally be expected to continue. Such areas deserve more favorable consideration for beach recreation development than those having a long-time history of erosion.

The sand dunes act both as a protection to property and as a supply of new beach material, and every effort should be made to preserve them. Gaps should not be cut in these dunes, and, where paths exist, they should be closed by sand fences and the area grassed over when the fences have been covered by wind-driven sand.

Consideration of the past history of inlets leads one to expect new inlets to open, migrate southward, and eventually close. Where desirable, the opening of a new inlet could be most economically encouraged by excavating to near the normal high water line to facilitate breaching by natural forces. Conversely, breaching could be discouraged by building artificial dunes in low areas where inlets are undesirable. This dune building can readily be started by the construction of sand fences.

Littoral current measurements, made in the course of beach erosion studies, are inconclusive as to direction and intensity of littoral drift along these shore lines. However, the southward migration of inlets, the extensive shoals off such points as Cape Hatteras, Cape Lookout, and Cape Fear, and the southeard trailing of numerous spits all indicate a general predominance of littoral drift to the south. Therefore, in general, when groins are placed in the ocean to stop littoral drift for the benefit of one beach area, there results a starving of the adjacent area to the southward. Accelerated recession of the shore line in the starved area is then to be expected.

The studies indicate that the Town of Wrightsville Beach must eventually stabilize the north shore of Masonboro Inlet and replenish the artificial fill between the present groins. The closing of Moore Inlet would give room for needed expansion and would probably postpone the necessity for, and reduce the volume of, replacement fill very materially.

The shore line at Carolina Beach is slowly receding. Future buildings should be located well back from the shore line in order to be safe from this slow encroachment of the ocean.

The Fort Fisher area is being eroded very rapidly. This recession of the shore line and a possible breakthrough of the ocean to the Cape Fear River could be prevented by the installation of a groin system in this area.

It is believed that these studies will inform interested parties as to the trend and rate of change in the barrier beach of North Carolina, and they may be used as a guide in future planning of beach recreational facilities. The information collected should also prove useful as a basis for continued studies to formulate more definite conclusions concerning the science of shore changes and shore processes.

Legislation--Federal laws pertaining to beach erosion cover investigations and studies made by the Chief of Engineers, Department of the Army, assisted by the Beach Erosion Board, in cooperation with agencies of States and Territories; investigations by the Chief of Engineers of improvements at inlets and mouths of rivers; general investigations with a view to preventing beach erosion and determining the most suitable methods for the protection, restoration, and development of beaches, and publication of data and information concerning erosion and protection of beaches and shore lines; and Federal participation in the cost of protecting the shores of publicly-owned beaches.

Cooperative Studies and Investigations--Public Law 520, 71st Congress, provides as follows:

a. The Chief of Engineers shall cause investigations and studies to be made, in cooperation with agencies of States and Territories, with a view to devising effective means of preventing erosion of shores by waves and currents.

b. Expenses thereof may be paid from funds appropriated for examinations, surveys, and contingencies for rivers and harbors.

c. The Secretary of the Army may release to appropriate State agencies information obtained from these investigations and studies prior to formal transmission of reports to the Congress.

d. No money therefor shall be expended in any State which does not provide for cooperation with the agents of the United States and contribute to the project such funds and/or services as the Secretary of the Army may deem appropriate and require.

e. The Beach Erosion Board, consisting of four officers of the Corps of Engineers and three persons selected with regard to their special fitness by the Chief of Engineers from among the State agencies cooperating with the Department of the Army, shall furnish such technical assistance as may be directed by the Chief of Engineers in the conduct of such studies as may be undertaken and shall review the report of the investigations made.

f. The salary of the civilian members shall be paid by their respective States. Traveling and other necessary expense connected with their duties on the Board shall be paid in accordance with the law and regulations governing the payment of such expenses to civilian employees of the Corps of Engineers.

Investigations of Improvements at Inlets and Mouths of Rivers--Public Law 409, 74th Congress, provides that every preliminary examination and survey report pertaining to such investigations, in addition to other information which the Congress has directed shall be given, shall contain information regarding the configuration of the shore line and the probable effect thereon that may be

expected to result from the improvement, having particular reference to erosion and/or accretion for a distance of not less than ten miles on either side of the concerned entrance.

General Investigations with a View to Preventing Beach Erosion and Determining the Most Suitable Methods for the Protection, Restoration, and Development of Beaches, and Publication of Data and Information Pertaining Thereto--Public Law 166, 79th Congress, provides as follows:

a. The Chief of Engineers, through the Beach Erosion Board, shall make general investigations with a view to preventing erosion of the shores of the United States by waves and currents and determining the most suitable methods for the protection, restoration, and development of beaches, and shall publish from time to time such useful data and information as the Board may deem to be of value to the people of the United States.

b. The cost of these general investigations shall be borne wholly by the United States.

c. All projects having to do with shore protection shall be referred to the Beach Erosion Board for consideration and recommendation.

d. The Beach Erosion Board, in making its report on any cooperative investigation or study under the provisions of Public Law 166, 79th Congress, shall state its opinion as to (1) the advisability of adopting the project; (2) what public interest, if any, is involved in the proposed improvement; and (3) what share of the expense, if any, should be borne by the United States. (General investigations do not result in the formulation of specific plans of protection or remedial works for a particular locality, since a separate study is required to develop such plans for each locality.)

Federal Participation in the Cost of Protecting the Shores of Publicly-owned Property--Public Law 727, 79th Congress, provides as follows:

a. It is the policy of the United States to assist in the construction, but not the maintenance, of works for the improvement and protection, against erosion by waves and currents, of the shores of the United States that are owned by States, municipalities, or other political subdivisions.

b. The Federal contribution toward the construction of protective works shall not in any case exceed one-third of the total cost.

c. The plan of protection must have been specifically adopted and authorized by the Congress after investigation and study by the Beach Erosion Board.

d. When the Chief of Engineers shall find that any such project has been contructed in accordance with the authorized plans and specifications, he shall, after appropriation by the Congress, cause to be paid to the State, municipality, or political subdivision the amount authorized by the Congress.

e. The Chief of Engineers may, in his discretion, from time to time, make payment on such construction as the work progresses. These payments, however, including previous payments, if any, shall not be more than the United States pro rata part of the value of the labor and materials which have been actually put into such construction in conformity to said plans and specifications.

f. The construction of improvement and protective works may be undertaken by the Chief of Engineers upon the request of, and contribution of required funds by, the interested State, municipality, or other political subdivision.

g. Federal participation in the construction of works for protecting privately-owned shores is not authorized.

Procedures for Cooperative Studies

a. By executive ruling, the agency applying for an investigation of any specific locality will be required to contribute 50 per cent of the estimated cost of the investigation. This contribution may be either in funds or services, as deemed appropriate and required by the Chief of Engineers, by authority of the Secretary of the Army. The studies result in a report containing plans and specific recommendations to improve or remedy a condition at a particular locality.

b. Any owner or group of owners of shore property on the Atlantic, Pacific, Gulf Coasts, and on the Great Lakes and the Territories, desiring to initiate the execution of a cooperative beach erosion control study, should first consult the appropriate State, county, or municipal agency with a view to such agency making application for the study.

c. The agency, on behalf of the property owners or on its own initiative, should discuss the erosion problem with the District Engineer and request a cooperative study, if desired. After such discussion and request, the District Engineer will present a preliminary analysis of the problem, a summary of all readily available data, and the purpose of the study to the Beach Erosion Board with a request for conference and inspection of the site by representatives of the Beach Erosion Board.

d. During this conference the preliminary analysis of the District Engineer will be modified, if necessary, and a work program will be formulated with itemized estimates of cost, which will be submitted by the District Engineer through the Division Engineer to the Beach Erosion Board for approval. The Board will advise the District Engineer of any changes in the outline of work believed necessary and the estimated cost of the Board's part of the work. The District Engineer will then estimate the total cost of the proposed study and will arrange the terms of cooperation and the completion of a formal application by the cooperating agency.

e. Most efficient coordination and prosecution of the work will normally be obtained when the District Engineer secures all of the information required for the report, with the cooperating agency transferring to the District Engineer funds in an amount equal to one-half of the total estimated cost of the study. Where this procedure is not satisfactory to the cooperating agency, the cost of the study may be divided by allocating certain phases of the work to the cooperating agency on the basis of estimated costs, with supplementary transfer of funds by the cooperating agency to the District Engineer in such amount as to make the share of the cooperating agency equal to one-half of the total estimated cost of the study. The estimated cost will be the estimated cost of performing the work by the District Engineer concerned, with credit normally to be allowed only for work performed subsequent to the consummation of the agreement covering the study.

f. The completed formal application, including a statement of the estimated cost and method of cooperation, will be forwarded to the Chief of Engineers with the recommendations of the District and Division Engineers. The Chief of Engineers will refer the application to the Beach Erosion Board for review and recommendation. Upon approval of the application by the Chief of Engineers, the District Engineer will be directed to proceed with the study in cooperation with the engineer of the cooperating agency.

g. Upon conclusion of the investigations, the Beach Erosion Board will submit its report, together with the reports of the District and Division Engineers embodying their findings and recommendations, to the Chief of Engineers for transmission with his recommendations through the Secretary of the Army to the Congress. Complete copies of these reports will be furnished the

cooperating agency. Where Federal participation in the cost of construction works is involved, a copy of the proposes report will be referred to the cooperating agency for its comments prior to submission of the document to the Congress.

Procedures of Federal Participation in Construction--Federal participation will require approval by the Chief of Engineers of detailed plans and specifications and of arrangements for the prosecution of the project, prior to commencement of work when executed by the local agency. Federal participation does not relieve local interests of the following responsibilities generally prescribed for that portion of the work which protects non-Federal real estate:

a. Maintenance and repair during the useful life of the works as may be required to serve their intended purpose.

b. Provision of all necessary lands, easements, and rights-of-way.

c. Claims for damages that may arise either before, during, or after prosecution of the work.

Construction will be performed by the local agency, unless it requests that the construction be undertaken by the Chief of Engineers and contributes its share of the funds therefor.

Cooperative Study at Carolina Beach--In view of the material damage to the beaches of North Carolina caused by recent tropical storms, the State Government is giving renewed interest to protection of tis coastal areas and has requested the District Engineer, Wilmington District, Corps of Engineers, to expedite completion of the cooperative beach erosion study at Carolina Beach. This study was started in 1952, and the sum of $4,100 was established as its estimated cost. Of this amount, $2,260 remained available for expenditure as of November 24, 1954. At that time, the District Engineer estimated that, due to work required because of damage and erosion caused by Hurricane Hazel on October 15, 1954, an additional $3,000, exclusive of available funds, will be required to complete the report. The District Engineer was of the opinion that, since it was not planned to increase the scope of the study, additional funds should not be required from local interests. He forwarded a recommendation to the Chief of Engineers through the Division Engineer, South Atlantic Division, that an additional allotment of $3,000 be made to complete the study and that a qualified engineer be assigned to his office, at the earliest practicable date, for temporary duty for a period of about three months. Such action was considered necessary because other high priority work made it impracticable for the only engineer in his office, who has had experience in beach erosion work, to devote his time in the immediate future to the cooperative study at Carolina Beach.

Public Law 875, 81st Congress--This legislation provides that, in any major disaster, Federal agencies are authorized when directed by the President to provide assistance to States and local governments, including performance on public or private lands protective and other work essential for the preservation of life and property, clearance of debris and wreckage, emergency repairs to and temporary replacements of public facilities of local governments damaged or destroyed in such major disaster, and contributions to States and local governments for such protective and other work, clearance, emergency repairs, and temporary replacements.

Executive Order No. 10427, January 16, 1953--This order designates the Federal Civil Defense Administrator as the official to foster the development of such State and local organizations and plans as may be necessary to cope with major disasters. The order provides that (1) Federal disaster relief shall be deemed to be supplementary to relief afforded by State, local, or private agencies and not in substitution therefor; (2) Federal financial contributions for disaster relief shall be conditioned upon reasonable State and local expenditures for such relief; (3) the limited responsibility of the Federal Government for disaster relief shall be made clear to State and local agencies concerned; and (4) the States shall be encouraged to provide funds which will be available for disaster relief purposes.

Hurricane Damages to North Carolina Beaches--The most destructive single force ever to hit Southeastern North Carolina caused severe damages to property on October 15, 1954, when Hurricane Hazel ripped across the beaches and roared on with stunning power to smash at virtually every town and community in the area. The Weather Bureau at the Wilmington Airport recorded the velocity of the hurricane as 98 miles per hour about 11:00 a.m. on October 15.

Ocean Isle Beach, between Shallotte Inlet and Tubbs Inlet, was wiped out almost entirely. Before the hurricane, there had been between 30 and 40 houses on the strand. After the passage of the storm, there was not a whole house still standing.

There were only two homes left standing on Long Beach, a long strand between Southport and Lockwoods Folly Inlet, on which there were, prior to the hurricane, some 250 cottages, in addition to other buildings.

Conditions at Holden Beach, between Lockwoods Folly Inlet and Shallotte Inlet, were equally as bad. A spotter-plane pilot for the Brunswick Navigation Company flew over the Brunswick County Coastland in the afternoon of October 15. He stated that the extent of the damage was unbelievable, that the damage at Wrightsville and Carolina Beaches was awful, and that the destruction at neither of these beaches could compare with the scene from the air at Long Beach, Holden Beach, and Ocean Isle, which was positively the worst thing he had even seen.

At Carolina Beach 200 to 300 houses were wiped out, one source reported. Only foundations were left in some instances, and in others not even a brick was left. The ocean, at some points, washed over four blocks of this resort town. It was said to be five feet deep in some places and two feet deep in others. Heaps of wreckage stood where they had been swept by the ocean. Paved streets were piled high with beach sand. During twenty minutes, the water rose eight inches in the City Hall, which was evacuated when the water was knee-deep.

At Wrightsville Beach, wrecked boats were on the shores of Banks Channel, and slanting timbers marked wreckage of piers and landings. Some streets were buried under sand. Where 14 beach cottages had stood, there were jumbles of splintered wood, with here and there a row of piles left standing. Homes elsewhere on Wrightsville Beach were damaged, and two fishing piers were badly wrecked. Harbor Island, between Banks Channel and the Intracoastal Waterway, suffered considerable damage, particularly to boats in the Marina and at piers of the Yacht Club. The sewage disposal plant, located on a small island connected by a causeway to the northern and of Wrightsville Beach at Moore Inlet, was severely damaged and was temporarily out of operation.

At Southport, every dock along the waterfront was destroyed, including nine piers on each of which there was either a gasoline fueling station or a shrimp house. Every shrimp house was blown completely away.

At Topsail Island, and particularly the settlements of Surf City and New Topsail Beach, the hurricane did considerable damage. More than 200 homes on New Topsail Beach were destroyed. The Surf City road was washed into in at least a dozen places over an 18-mile stretch.

At Atlantic Beach, on the eastern end of Bogue Banks extending between Beaufort Inlet and Bogue Inlet, several buildings between the Ocean King Hotel and the Atlantic Beach Hotel, were seriously damaged.

Disaster Relief Meeting--The Governor of North Carolina called a conference in Raleigh on November 22, 1954 of federal, state, and local officials, the Governor's Disaster Committee, and representatives of coastal towns and counties for the purpose of planning action to be taken regarding property damage in North Carolina, caused by Hurricane Hazel and estimated to amount to more than 120 million dollars.

The Governor indicated that the State had allocated $100,000 for hurricane relief and expressed great interest in what remained to be done and what could be done, particularly to repair the beaches.

The State Director of Civil Defense reported that applications, involving expenditure of approximately $2,000,000 for emergency repair of publicly-owned facilities and emergency beach repair, had been transmitted to the Federal Civil Defense Administration for approval.

State Disaster Relief Office--The Council of State, after setting aside $36,500 of the allocation of $100,000 for hurricane relief, made available $10,000 for engineering aid to repair beach erosion. A State Disaster Relief Office was established in the City Hall, Wilmington, North Carolina, on November 26, 1954, for the purpose of furnishing advice and technical assistance to local governments in connection with beach-rebuilding work under the provisions of Public Law 875. An engineer, employed by the State Department of Conservation and Development and having had experience in beach erosion work, was placed in charge of the office. The State Director of Civil Defense and representatives of the Federal Civil Defense Administration and the State Department of Conservation and Development met, in Wilmington, Beaufort, and Southport on December 1, 14, 15, and 16, with representatives of local governments for the purpose of providing assistance in connection with applications for Federal financial aid in disaster relief work and with required documentation covering such aid.

Reconstruction--As of December 15, 1954, at all of the beaches, construction, or reconstruction, crews were working to clear away the debris and to restore such buildings as were not beyond repair. Many persons, who have not settled their claims with their insurance companies, were going ahead with their repairs. It was already clearly evident that the rate of reconstruction will be stepped up from week to week, that a considerable amount of finished construction will be ready for occupancy in the summer of 1955, and that it will not take the years predicted by pessimists to restore the beaches to their past glory. It no longer seemed too much to hope that, by July 1955, enough new construction will have been completed to attract large numbers of vacationers, tourists, and fishermen to the North Carolina coastal resorts. It was

estimated that impetus would be added to this program by accelerated action of insurance companies in settling claims and by work of local governments, assisted by the Federal and State Governments under the provisions of Public Law 875 and including rebuilding of dune lines to protect life and property, to prevent beach erosion in the future, and to restore the stands in many places.

Principles Applicable to Law Governing Water Use - - In general, the laws of the United States lag seriously behind the requirements of the day. Three general principles have been applied to law governing water use.

The Old English law of private property followed the doctrine that, when one held title to land, he also had title to all physical appurtenances thereto. His property was all that was encompassed within the exterior boundaries, from the center of the earth to the heavens. He had property in a stream flowing through or by his holdings. He could use it, but the next property owner downstream also had the same rights to that water, known as riparian rights. The English law held that each landowner along a stream is entitled to the original, unimpaired flow. In the case of ground water, the English law held that, when supplies of ground water were within the boundaries of a man's property, he could pull on it as he willed. There was no recognition that ground water is water in transit as much as water in streams. The principle of riparian rights still has considerable governing force in North Carolina and the other older States of the East.

The second principle, an outgrowth of a number of court decisions, is known as the American rule. It recognizes the right of all those having access to a water supply to utilize the resource if theirs is a reasonable use. Applied to ground water, for example, this doctrine recognizes that all lands, overlying a common subterranean supply in a ground water basin, have correlative and coequal rights to use that water. But it is not a reasonable use if one landowner so overdraws the water that it deprives other land owners from making reasonable uses of that supply. The deficiency of the reasonable use doctrine lies in not recognizing priority in use. Latecomers may make use of water that is reasonable, but in so doing they draw water from users already established and dependent on that that same water supply. It does, however, recognize the necessity of equitable apportionment when drought comes.

The third general principle governing water use is that of prior appropriation. It is the principle, often with legislative acts defining it, which applies in the Western States. The rancher who has already established his rights has first call on the flow of a stream, and later users have to let the water flow on down the channel to satisfy the rights of earlier appropriators. The laws in Western States were drawn to meet the demand for irrigation water with very slight regard for other water users. Cities often have to buy out irrigators in order to secure the rights to water. Industrial users encounter the same priority titles of irrigators.

Existing Water Laws in Various States - - A number of states have laws relative to ground water. Arizona law gives authority to regulate wells drawing more than 100 gallons per minute. Indiana law regulates wells only if they pump at the rate of more than 200 gallons per minute. New Jersey has had legislation regarding ground water since 1910. The newer laws are in the right direction toward planning for all users and preventing misuses. They take into account interference of wells with other wells. They regulate withdrawal so that there will not be water supply taken out of underground supplies more rapidly than can be replaced by inflow. They provide legal basis to prevent the pollution of underground water through improper sewage disposal.

The pressure on ground water supplies, the shortages that have resulted from overdraft, and the forced turning to ground water brought about by making surface water unusable are driving states toward some sort of ground water control legislation.

Proposed Rain-increasing Legislation - - Another somewhat spectacular water-law puzzle has arrived with the advent of the scientific rain maker, or more exactly, the rain increaser. The seeding of clouds with silver iodide for the purpose of chilling them and inducing them to drop more moisture over one state has brought threats of action on the part of other states which would have received benefit from those same clouds later in the natural course of their travels. Precipitation of high value to one person or group may flood another group. It is open to question how any court could determine damage or benefit from cloud seeding. Some states, however, are considering drafts of legislation regarding this new adventure in the field of use of water resources.

Water-Legislation Considerations-- There is a wide variance between the laws of different states applying to water. Court decisions inject other differences as laws are interpreted. To some extent, the different state laws only reflect the difference between climatic, physiographic, and social regions. There always will be such differences. The laws which might be directed to the best use of water-wealth in one region are not those which should govern in another.

Water legislation should recognize two universal principles. The first of these is that any user of water may have the right of use, but that water as such is public wealth, and whoever does make use of it must release all that is left in a condition which will not prevent good uses while the water is in transit.

The other precept that should be recognized is that no laws shall so freeze water to any one use as in effect to create a monopoly. For example, no law should provide for minimum flow in a channel to maintain navigation, necessitating release of water from impounding reservoirs, which also serve irrigation, at a time which would spell disaster to farmers, and no law should provide for minimum rates of flow below an impoundment for hydroelectric purposes which will destroy a fishery of large value.

Legislation should point toward securing a balanced use of water. As it is, the law, having grown up through fragmentary and first-come demands on the whole of water wealth, has in no small degree established obstructions to what must be done to secure the greatest return from all uses of water.

Change can be secured through legal action, which should provide a solution of problems before too great damage is done by abuse and misuse of our water resources. We are at a point where our water wealth must serve all uses in a balanced plan of management. Uses in such plans must have a position in proportion to their value to the community as a whole. Since the law supplies the rules whereby such uses may be achieved, it must be flexible and forward looking enough to supply the legal basis for achieving these uses.

Recent Studies of Water-Legislation in Various States - - South Carolina began work in 1953 on a new law based on the doctrine of prior appropriation, the western doctrine. The proposed law, which would establish a new water policy for South Carolina, is contained in the report submitted to the General Assembly of South Carolina of 1954 by the Joint Committee appointed pursuant to a joint resolution of the General Assembly of 1953. Under the proposed law, a newly created Board of Water Commissioners of the State of South Carolina would issue permits for

water on a priority basis in this order: domestic, municipal, irrigation, industrial, recreational, and hydroelectric power.

It is understood that the proposed legislation was not introduced in the South Carolina General Assembly of 1954, because hearings thereon had not resulted in reconciliation of views of conflicting interests. Most observers in South Carolina believe that the new water doctrine will be enacted by the General Assembly of 1955. There is pressure for it. Drought-stricken farmers, who realize the future of irrigation, realize also that they will be hard put for getting water for irrigation if some orderly system of legal use of water is not established.

Chances are good, too, that water legislation might come up in Georgia's legislature next session. And in Alabama, Mississippi, Michigan, and half a dozen other states east of the Mississippi River, consideration is being given to new water-use legislation.

Extension of Water Facilities Act - - The Congress of the United States, during its 1954 session, extended the Water Facilities Act to cover the entire country. Formerly limited to the 17 western reclamation states, this act makes loans available to individual farmers or groups for development of farm water supply or irrigation systems. With the East and South becoming more interested in supplemental irrigation, as a result of the drought, the broadened act will encourage better use of farm water and further increase the demands for use of water for irrigation purposes.

Legal Situation in North Carolina regarding Use of Water - - This situation is as follows. In addition to the principle of riparian rights, as established by the old English law of private property and interpreted from time to time by decisions of our courts, there is only one North Carolina law pertaining to the use of water. This law is contained in sub-section 113-8.1 of General Statutes of 1943, as amended, and reads as follows. "Any person, firm, or corporation utilizing waters of North Carolina taken from the streams, rivers, creeks, or lakes of the State in such an amount as to substantially reduce the volume or flow thereof for the purpose of irrigation shall before utilizing this resource in this manner make application to the Director of the Department of Conservation and Development for a permit for such use. Such person, firm, or corporation shall file with the Department of Conservation and Development a proposed irrigation plan and survey. The Director of Conservation and Development is hereby authorized to investigate such a plan as to safety and public interest and to approve plans and specifications and issue permits."

It may be noted that this law is not punitive. Any user of surface water for irrigation is merely a law violator and may continue his illegal use without fear of retribution, other than action in a court of competent jurisdiction pertaining to dispossession of riparian rights. It may also be noted that the law is silent with respect to use of ground water for irrigation. Any user of ground water for irrigation may legally use any volume of ground water which he desires without any action on his part other than the operation of his irrigation equipment after he has installed it on his property.

North Carolina Action toward New Water Legislation - - At the meeting of the Board of Conservation and Development in Raleigh in January, 1954, the Board adopted a resolution calling for an up-to-date Water Code for the State, and for the conservation and wiser utilization of North Carolina's water resources. The resolution also called on the Governor to appoint an advisory water committee of seven men to work with the Board's Committee on Water Resources in formulating such a program as called for in the resolution.

At the meeting of the Board of Conservation and Development in Wilmington in March, 1954, the Director of Conservation and Development called attention to the formation of the Governor's Advisory Water Resources Committee to work with the Board's Water Resources Committee in the formulation of a new State Water Code.

At the meeting of the Board of Conservation and Development in Morehead City in July, 1954, the Board heard a statement by the head of the Division of Water Resources, Inlets and Coastal Waterways, Department of Conservation and Development, that a law on water policy, similar to the act recently considered by the General Assembly of the State of South Carolina, should be prepared and, after revisions resulting from consideration by the North Carolina State agencies concerned, representatives of business, industry, utilities, railways, wildlife groups, and farm organizations, presented to the North Carolina General Assembly for enactment. The statement included an expression of the belief that the proposed law on water policy should require that all users of surface waters secure permits from the Department of Conservation and Development.

The Chairman of the Governor's Water Resources Advisory Committee, in addressing the Board of Conservation and Development at their July, 1954, meeting, suggested that the General Assembly should be asked to enact a water use policy for the State. He said that the increasing competition for water for industry and agriculture will lend greater urgency to such legislation. He emphasized the State's needs for a new water regulation and use law and pointed out that a long range policy involving water-users in North Carolina is needed. He said that the water laws of the State are out of date and inadequate. There is also a need for an educational program to acquaint the people with the problem, he added.

South Carolina Water Legislation Studies - - As stated heretofore in this chapter, South Carolina began work in 1953 on a new water law. Actually, studies pertaining to water-use problems in South Carolina have been in progress for about six years.

In 1945, soil conservation districts in the Coastal Plains of South Carolina asked for help on the problem of excess water and drainage. In 1948, a meeting was held for more intensive study of the Coastal Plains problem. Two more conferences followed in 1949. At the second of these two conferences, the group agreed "that any program considered should not be limited to drainage but rather should be one of overall water management, including the control and impounding of water for prevention of soil erosion and its utilization so that all sections of the State would benefit." Soil conservation district leaders soon realized that water-use is a problem concerning all of the people. They recognized that all water users must have a voice and a hand in solving the problem.

In the fall of 1950, added impetus was given to the study. At that time, a meeting of South Carolina Soil Conservation district supervisors was held in Columbia. Representatives of many Federal and State agencies, farm groups, railroads, utility companies, and industries attended the meeting. The conference adopted the following resolution:

1. That the importance of water as a resource is recognized;
2. That the President of the Soil Conservation District Supervisors is authorized to name a steering committee to join with the State Research, Planning, and Development Board in starting a water management program for the State; and
3. That it is the sense of the conference that funds be requested from the General Assembly to promote such a program.

In 1951, the State Soil Conservation Committee took as one of its first jobs the finding of an effective way to handle the State's water problems. The Committee sought the advice of Dean Samuel L. Prince, of the University of South Carolina School of Law. Then came more and more questions from farmers through their soil conservation district supervisors, asking the State Soil Conservation Committee to help solve specific water-use problems. Demands for water were highest when water was scarcest during droughts. Conflicts were rising between and among farm, factory, and city water-users. Existing water laws seemed inadequate to resolve these conflicts with justice to all water users.

With these problems before them, the State Soil Conservation Committee requested help from the Regional Director of the Soil Conservation Service in locating qualified personnel. In May and June, 1952, Mr. C. E. Busby, Soil Conservation Service specialist and an engineer, geologist, and attorney specializing in water rights, was lent to the State Soil Conservation Committee for an on-site survey of the State's water problems and an intensive study of South Carolina water law. Dean Prince worked closely with the State Committee and Mr. Busby.

Following this study, numerous conferences were held with leaders in related fields. At each of these conferences, the State Soil Conservation Committee was asked to take the leadership, with assured support from other water-using groups. The representation at one meeting arranged by the Governor and the State Committee illustrates the cooperative effort and the attempt to secure from every source the best thinking on the subject. Represented were:

Clemson College (previously engaged in research and educational work to help show the value of water to agriculture), the Soil Conservation Service, the Extension Service, the State Experiment Station, the Commissioner of Agriculture, the Department of Research, Planning, and Development, the State Department of Vocational Agriculture, the State Forestry Commission, the Farmers Home Administration, the State Association of Soil Conservation Districts, the Attorney General's Office, the South Carolina Water Pollution Control Authority, the Production and Marketing Administration, the State Farm Bureau, the State Grange, the University of South Carolina, the South Carolina Municipal Association, South Carolina Division of Game, the South Carolina Electric and Gas Company, the General Assembly, railway officials, the State Chamber of Commerce, and the Governor's office.

In March 1953, the General Assembly adopted a joint resolution, setting out the State's water policy and authorizing the appointment of an 11-man Water Policy Committee to recommend ways of putting this broad policy into effect. The resolution declared that this policy is to give to the State the control of the development and use of water for all beneficial purposes, and that administration of this policy shall seek to bring about full use and protection of the water resources of the State.

The Water Policy Committee, in their report submitted to the 1954 General Assembly of South Carolina, made the following statements:

"The philosophy of the 'best use for all the people' has been constantly in the mind of the Water Policy Committee and in drafting recommended legislation. Indeed, study of existing water law leads to the conclusion that the General Assembly must enact new laws if this philosophy is to have any desirable effect on the daily life of South Carolinians.

We emphasize at this point that our recommendations do not disturb existing vested rights of water users. This is in keeping with a specific pro-

vision of the joint resolution; it is also a specific provision in the proposed water law.

We should emphasize also that the proposed act does not in itself hold a complete and final solution to all the problems of water use. There will remain the problem of land use. The water we use, regardless of where we live, comes from the land. We begin to measure our available water when it reaches the ground as rain or snow. How much of it we can control, hold, and use depends a great deal on what kind of land the rain or snow falls on. Soil conservation does more than save soil. The terraces, cover crops, contour plantings, permanent pastures, farm ponds, and planting of trees promoted under the program also save water. These measures slow down the run-off of rainfall and help the soil soak up the water, storing it for further use. So, a new law that makes water more useful and points up its value should bring added support to conservation measures."

Further extracts from the Water Policy Committee's Report follow.

The alternative to a new law is to leave the present inadequate law in effect. This would allow present conditions to continue and to become increasingly confused and inequitable. It would mean that much of the value of our water resources would be lost.

The very development of our state exerts an increasing demand on our water resources. Certain factors are already at work which indicate the critical situation in our State. The first of these is our increasing use of water for industrial use, for municipal use, for agricultural use, and for recreational use.

It is important that we find some way to even the flow of water as far as man can. This will mean greater attention to soil and water conservation. Poor landuse means that rainfall rushes across the land and down the streams in a short-lived peak. Uncorrected, rainfall sweeps across the land and downstream at ever-increasing speeds. It also carries more and more valuable topsoil with it.

Another phase of South Carolina's water-use problem is that of storage. This problem becomes more acute each year. Power companies have been the chief builders of dams in the State, storing water to use for generating electricity. In virtually every instance, a special law has been passed by the Legislature to permit each project. Dams on a much smaller scale are planned or are in use by farmers who are pooling their funds for irrigation work. As the scale of this type of cooperation increases, conflicts in storage and water rights are inevitable.

South Carolina needs laws that answer the following questions:

Can the State, under its present law, aid in the construction of storage dams and basins? Are farmers on safe ground legally in undertaking joint storage and irrigation projects on a small scale? Can water be diverted from a stream in periods of peak flow into storage ponds?

On their own lands, South Carolina farmers built more than 5,000 storage ponds as a start toward better storage and more evenly-distributed water supplies. These are ponds that collect surface drainage waters. The problems of storing surplus stream water remains. We need a sound legal foundation on which to build a pattern of wise, just, and efficient water-use.

Perhaps the problem of storage, better than any other one factor, spotlights the dilemma in which our seasonal variation in rainfall leaves us. With too much rainfall the State suffers from erosion, floods, and water-logged lands. We need better physical means to store this surplus for use during droughts. Existing laws handicap our efforts. With too little rainfall, competition for water becomes acute. Existing laws handicap our efforts to decide whose claim to water is best and what share each user should get.

Our chief concern as a committee has been to determine the provisions of a law that will place the resources of the State to the best use for all her citizens. At the present time, the Committee recommends an act covering only surface water. We believe that a study of ground water should be made as soon as possible. This study could serve as the basis for further legislation. From this study may come recommendations for legislation on ground water problems, fully as important as and closely related to surface water problems. The main purpose of the law now proposed is to provide the legal foundation for balancing supply and demand for our surface water resources. Obviously, no law can produce more water. It can only settle the question of how we shall share and use our water.

Our proposed law calls renewed attention to the fact that we must do a better job in the actual handling of our surface water. The work of the conservationist and agricultural engineer takes on new significance. Here is a case of the whole being greater than the sum of its parts. The law can make more firm the individual's water rights and provide greater incentive for joining in conservation programs to use land and water wisely. In turn, the conservation program will mean better physical control of water, making provisions of the law more meaningful. In concert, these two approaches should continually serve to re-inforce each other.

In his report to the State Soil Conservation Committee, Mr. Busby summarized very well the present position of South Carolina, as follows:

"The problem of providing adequate supplies of water and land for all needs in this State presents the same general type of situation that has occurred throughout the western 17 states in one form or another. The only real difference is one of degree. The principles are essentially the same though the factual situations differ. Wherever water shortages arise, greater definiteness and dependability of water rights and water supplies to satisfy those rights must be provided.

When water was plentiful for all, and uses did not materially reduce the total supply, the old riparian doctrine was adequate. But in the very complex economy of today, riparian law has been found by hard and costly experience to be inadequate in certain respects. It is essential to the continued development and expansion of agriculture, industry, and municipalities in this State that a more adequate doctrine of law be established with due regard for the vested rights of all present water users, riparian or otherwise. Adjustment in the basic property law of surface water rights should precede that of ground water rights.

South Carolina water users are today wondering whether or not their investments in water development and land are secure in view of the shortage of water occurring as a result of expansion of activities. They are beginning to discuss these matters in groups as did the miners of California (extracting gold from the stream-beds) when they developed the 'custom of the diggins'-the origin of the western doctrine of prior appropriation. Some (of the South Carolina water users)

are also taking the second step that occurred out West by asking county recorders to record their claims to, and intention to use, definite and specific quantities of water at given places.

The doctrine of appropriation has been adopted in every state of the West in order to encourage development and to protect investments dependent upon water supplies. This experience has been thoroughly tested in the courts, in the administrative agencies, and in the cooperative activities of water users. It is not a perfect or utopian system. But it may be wise to take full advantage of it."

The Water Policy Committee drafted a bill to be presented to the 1954 session of the General Assembly. In this bill, the Committee tried to incorporate the best thing of people from public and private agencies involved in the use of land and surface water in our state.

The new bill guarantees existing vested rights to surface water that is being used for beneficial purposes (the best use for all the people); it provides for an orderly, legal way for additional uses to develop. The bill proposes that, as of the effective date of the act, a person's right to appropriate, or use, surface water shall be in compliance with the provisions of the act.

No person shall take water from a stream, lake, or other watercourse without having a valid right to do so. Violators are subject to fine, or imprisonment, or both, at the discretion of the court. Exempted are those who build ponds on their own lands to collect surface water which drains from such lands, or whose lands contain a pond or lake with no natural outlet. They have absolute ownership in such water.

Persons must apply for the right to use surface water in watercourses or to dam it for use, with the exceptions mentioned just above. The use of surface water shall be subject to the principle of beneficial use. The act defines beneficial use as "that which is for some useful industry or to supply a well recognized want." Appropriation, or use, of water, on and after the effective date of the act, for different purposes shall take precedence in the following order: domestic, municipal, irrigation, industrial, recreational, and water power uses.

The bill authorizes the Governor to appoint with the consent of the Senate a Board to administer the water policy. The Board shall regulate and control the development, conservation, and allotment of the surface water of the State according to the principle of beneficial use and priority of appropriation, or use, established by the Act. The Board will issue permits upon approval of applications to divert water. Within 60 days after construction is completed and water put to beneficial use, the Board will make an inspection and issue a license.

The Board shall make a survey of the ground-water resources of the State. An inventory of the development and use of ground water shall be made through cooperation with the private and public users concerned. The Board shall seek a resolution to the ground water problems as they affect the development and use of surface waters and land.

What will adoption of such a law mean to South Carolina? The Committee believes the principal benefits will be two:

1. Orderly and legal development of water resources with greater security of investment in such development; and

2. Better and more complete use of our abundant water supply.

With the authority granted under the proposed law, the Board can establish a priority of rights to the water in any stream or lake. A new user will then know the maximum amount of water he can take under normal supply conditions. In the event of reduced stream flow, he knows in advance how many users have earlier claims to the available supply. He is aware of his risk before he makes his investment. Such a system should lead to the development of every surface water resource to its fullest potential.

Such a system should also promote land development. No longer will a user have to own riparian lands to use water. A site better suited for particular use can be developed without regard for its immediate proximity to water. Through judicious allotment of water rights, the Board can promote this development.

Adoption of this bill should mean less waste of the State's water resources. The supplying of a useful industry or a well-recognized want now becomes the yard stick for allotment of water. No longer must use of water be limited by the right of every downstream user to have the same amount and quality of water flow by his land. Subject to the judgment of the Board, a person may obtain as much water as he needs without regard for what is left for others downstream. In this manner, the Board can prevent millions of gallons of water flowing unused to the ocean-millions of gallons that belonged to riparian owners in common but usable in quantities divided so finely as to be worthless. By careful planning, the Board can permit withdrawals of water down the length of the watercourse so that no unnecessary amounts of water flow unused into the ocean. This type of planning, coupled with anti-pollution and other quality controls, also will encourage the return of the water to streams and rivers for repeated use throughout the length of the watercourse. With such a law, South Carolina will have a water law that recognize the needs of the times. Is not the history of our legislative process one of adapting the law to fit the needs of all the people while protecting individual rights?

CHAPTER XVIII--CONCLUSIONS

Analysis of the preceding seventeen chapters has resulted in formulation of the following conclusions.

REGIONAL CHARACTERISTICS AFFECTING WATER RESOURCES

1. Each region has its own characteristics of geology, topography, temperature, precipitation, and evaporation which, collectively, determine the quantities of water that are available from place to place and season to season, and, therefore, whether water will be plentiful or scarce.

2. Geology affects natural drainage, runoff, and the storage of ground water.

3. Topography affects the rate of concentration of storm water in streams, the rate of percolation of water into the ground, stream gradients, rates of travel of flood peaks in various sections of a stream, and the timing of the concentration of tributary flow in the main channels.

4. Temperature affects the rate of evaporation and the rate of runoff.

5. Temperature and precipitation provide primary controls over the total amount of water that is available throughout the year. Drought comes when there is a lack of rain and a rise in temperature.

6. The combination of soils, vegetation, topography, temperature, and rainfall collectively determine the amounts of water that occur in the ground and on the surface during the various months of the year.

SHORTAGES OF WATER

7. Unless the misuse of water wealth is checked, and sound principles of conservation and proper use of water are adopted, more and more shortages of water will occur.

8. The average annual precipitation in the United States is about 30 inches. The average annual precipitation in North Carolina is about 49 inches. The people of North Carolina will have plenty of water if they conserve it and use it wisely. They should cease to harbor the illusion that water resources are inexhaustible.

9. The uses of water are increasing ever more rapidly in all categories. It is estimated that the Nation's water requirements in 1975 will be approximately twice as great as the requirements in 1950.

10. The monetary loss to agriculture in North Carolina caused by the 1954 drought, is estimated at fifty (50) million dollars. During 1953 and 1954, twenty (20) countries and thirty-nine (39) counties, respectively, were declared drought areas by the Federal Government. These situations indicate the ever-increasing need for conservation of the State's water resources. Action must be

taken to store water in times of abundance in order to provide for requirements in times of scarcity.

USE OF WATER FOR DOMESTIC AND MUNICIPAL PURPOSES

11. The use of the State's resources for domestic and municipal water supply must have first priority in the consideration of water resources development. Accelerating demands for water by cities are beginning to add up to a significant load on the water resources. Evidence indicates that the use of water by municipalities tends to show a greater rate of increase than all other uses.

12. It is estimated that 330 million gallons of water were used daily during 1950 for domestic and municipal uses in the State. In the past 20 years, our population has increased 28 per cent, and the use of domestic and municipal water has increased over 75 per cent. Therefore, it is estimated that 725 million gallons will be used during 1970.

13. As water use increases, the control of water becomes more necessary to insure adequate supplies, abate stream pollution, protect property from flood and erosion damage, and enlarge recreational opportunities. The saving of water, the proper channeling of it, and the prevention of huge losses become a major problem of public interest and concern.

USE OF WATER FOR AGRICULTURE

14. Increased storage of water, both for general farm operations and for the farm homes, is becoming a major requirement for the immediate future.

15. Irrigation is a major aid to increasing crops from acres in cultivation. The quality and quantity of crops are increased by irrigation.

16. The use of water in North Carolina for irrigation is increasing greatly.

17. Owners of land on the banks of streams must be protected against the construction of dams or other damaging uses of water by owners of land above them.

18. Legislation covering the whole water problem is needed.

19. Farmers are making mistakes in purchasing irrigation equipment. The program of education with a view to preventing recurrence of such mistakes should be expanded.

20. Detailed surveys of soil conditions on areas to be supplied with water, and analyses of such surveys, should be effected before proceeding with development of a new irrigation project or extension of an existing project.

21. The advantages and disadvantages of various types of irrigation equipment should be carefully studied, and costs of an irrigation system should be compared with the anticipated profits therefrom.

22. Increased use of water for irrigation is raising questions regarding water rights, and a sound legal foundation, on which to build a pattern of

wise, just, and efficient water-use, and by which determination as to whose claim to water is best and what share each user should get, is required.

USE OF WATER FOR INDUSTRIAL PURPOSES

23. Water in tremendous volume is constantly serving industry, and major consideration should be given to insuring adequate supplies of good water for such uses in the future.

24. The ultimate solution to the problem of adequate resources for public and industrial use is to be found only in long-range planning by water suppliers and users. Such planning must provide for the intelligent development, utilization, and conservation of local and regional water resources, in line with established and anticipated needs.

USE OF WATER FOR RECREATION

25. The recreational use of lakes in North Carolina has grown to the proportions of big business. The demand for lake sites for permanent homes, as well as summer cottages, may make profitable the construction of dams to create lakes.

26. The streams of North Carolina in past years lost much of their value for recreation with the increase in urban population and industrial activity which resulted in stream pollution.

27. Recreation is now of such importance that it is provided for, wherever practicable, in the planning of flood-control, water-supply, and hydroelectric reservoirs. Fish and wildlife constitute a resource of major importance, both commercially and from the standpoint of recreation.

USE OF WATER FOR HYDROELECTRIC POWER

28. The power possibilities of North Carolina rivers have not been completed. It appears, however, that the remaining undeveloped potential hydroelectric sites in the State, which are not now under consideration for future development, are not large in relation to the total capacity of hydroelectric and steam plants now in operation.

29. Experience with privately-owned power companies under State supervision and regulation well justifies the faith of the people of the State in the ability of private enterprise to supply its need in this field.

30. The undeveloped sites, even if they could be developed economically, would contribute but a small portion of the huge additional electric energy demands expected to occur in the future. Dependence for satisfaction of these demands will probably be principally placed on large, modern, and efficient fuel-burning electric-generating plants.

SURFACE WATER

31. Soil conservation, reforestation, and detention reservoirs, are of great importance for storage during periods of abundance of water for the purpose

of having available supplies of water for use during periods of drought.

32. The only dependable and accurate method for determining the rate and volume of water carried in our streams is to make continuous, or at least daily, observations of stream flow at selected places.

33. Information regarding quantity and quality of surface waters is important in connection with water supply, drainage, disposal of wastes, highway design, recreational development, irrigation, and navigation.

34. Accurate topographic maps are regarded as a prerequisite for developments and programs involving land and water utilization.

35. It is estimated that there are approximately 2,000 farm ponds in North Carolina. The number of these ponds is steadily increasing because of the drought during the past two years.

GROUND WATER

36. A considerable part of the money spent for drilling, boring, and digging new wells in North Carolina is being wasted because of a lack of adequate information on ground-water conditions.

37. Many of our problems are concerned with providing information which will make possible the proper use of ground water.

38. There is a need for greater knowledge of the changes in ground-water supplies, the effects of greater concentration of pumping, the seasonal effects on water levels, and the rates of replenishment of ground-water supplies.

QUALITY OF WATER

39. Information on the chemical character of surface waters is essential to the locating of many industries, to a better and more economical use of water by both industries and municipalities, to planned coordination in the most advantageous use of water for industry, public supply, agriculture, and recreation, and to the conservation of fish and wildlife.

40. The suitability of water for man's needs is dependent on its sanitary and chemical qualities.

41. Much useful information regarding quantity and quality of water are being obtained through the cooperative programs of the North Carolina Department of Conservation and Development and the Geological Survey, United States Department of the Interior, in the execution of which the Federal Government matches the funds made available by the State.

ABATEMENT OF STREAM POLLUTION

42. The State Stream Sanitation Committee was created by the General Assembly in 1951 as the agency responsible for the quality of the water resources

of the State and authorized to protect the water requirements for health, recreation, fishing, agriculture, industry, and animal life.

43. During the four years of their existence the Committee have (a) established classifications, and the standards applicable to each such classification, which will be appropriate for promoting most effectively the water requirements indicated above, (b) effected final adoption and assignment of classifications to the waters of the Yadkin River Basin, (c) completed all detailed investigations and stream sampling work in, and substantially completed comprehensive reports on, the White Oak and Chowan River Basins, (d) completed field and laboratory studies for the Roanoke River Basin, (e) completed the stream sampling program, and calculated and compiled the laboratory data, for the French Broad-Pigeon Basin, (f) completed routine samplings, investigations of significant sources of pollution, and water and land uses on the Haw and Deep Rivers, source-tributaries of the Cape Fear River, and (g) practically completed stream sampling work in the main stem of the Neuse River and tributaries thereof above a point on the Neuse River immediately below Raleigh.

44. Considering the lengthy procedures of the work of the committee, prescribed, in the interest of the people of the State, by the legislation which established the Committee, it is believed that they are accomplishing effectively and without delay the protection of the water requirements in the best interest of the people.

SOIL CONSERVATION

45. Soil erosion and run-off from the land can be reduced, thereby causing substantial reductions in floodwater and sediment damages, preserving fertility, and increasing infiltration rates to place more water in the soil to be available for plant use during dry periods, through proper land-use practices, including strip cropping, contouring, terracing, reforestation, retention of water by grasslands, stabilizing and sediment control structures, and upstream floodwater-retarding structures.

46. The amount of water we may have for our needs and how we may use it depend on good or bad management of our watersheds. We must do what we can, under the conditions of soil, water, and plant-cover now existing, to secure the best use of the soil-water wealth we have in our watersheds. Maintenance of soil coverings on drainage basins is a matter of great urgency.

47. Forest crops should be harvested from high basins in such a manner that the watersheds in those basins will be improved. Contour planting of row crops, building of terraces, maintenance of organic matter in the upper soil, putting steeper slopes in permanent pasture, and construction of farm ponds should be encouraged. There should be less draining of swampy areas in the higher reaches of catchment basins. Water should be retarded in its travels from where it falls, particularly in higher gathering basins. Efforts to adjust forest uses equitably should be supported. Any move to increase soil mat and grass cover should be encouraged. Pasture practices should include good grazing and ground-protection conditions. The highest possible usability of water throughout the line of transit from the point of precipitation to its juncture with the ocean should be maintained.

WATERSHED MANAGEMENT

48. The control of water for more beneficial use by man, in order to use land more intensively and to limit soil erosion, sedimentation, and flooding, has never been so urgent as at present.

49. Successful watershed management must have as its basic background sufficient reliable data for a comprehensive study of all factors pertaining to water resources. Topographic mapping, the essential foundation for geologic, hydrologic, and soil maps, is one of the sources of the required basic data. North Carolina ranks far down the line in topographic mapping when compared with the majority of the other States. Hydrologic maps, with topographic and geologic maps as a base, are prerequisite for intelligent planning and development of water-resources projects.

50. To forward a sound national policy for the conservation, development, and sustained use of our land, water, and related natural resources, the States should enact adequate legislation, in advance of the increasing demands on the water supply, to determine the respective rights of water-users and settle "whose water is it?"

51. Nearly every State in the eastern half of the Nation is now considering fundamental water legislation.

52. The importance of balancing supplies of water with needs for water at a given time and place should be stressed.

53. A combination of upstream improvement and downstream improvement is necessary. Upstream improvement is complementary to downstream improvement and vice versa.

NAVIGATION

54. The Corps of Engineers, Department of the Army, in discharging the responsibility for navigation-improvement assigned to this organization by the Congress of the United States in 1826, have, since 1828, improved 1,100 miles of navigation channels in North Carolina, of which 41 miles are for deep-draft ocean vessels, and have expended more than $15,000,000 to construct channels and harbors for shallow-draft vessels, and $6,200,000 for deep-draft vessels.

55. Investigations of proposed navigation projects are made by the Corps of Engineers upon direction of the Congress. Each project must be authorized by the Congress prior to appropriation of Federal funds for construction of the project. No project is authorized unless the ratio of the anticipated annual monetary benefits to the estimated annual charges is greater than unity. The benefits include savings in transportation costs by operation of deeper-draft vessels, elimination of necessity for partial cargoes, and reduction in delays awaiting favorable tides. The charges include interest on the investment, amortization, and maintenance costs.

56. In the waters of North Carolina other than those contained in the Cape Fear, Neuse, Tar-Pamlico, Roanoke, and Chowan River Basins, there are 12

completed projects, 12 partially completed projects, 2 authorized projects for which no funds have been appropriated, and 15 projects which are under investigation directed by the Congress.

57. The condition and permanency of inlets is of vital importance to the present and future economy of the Coastal Plain. Attempts to dredge new, or maintain old, inlets may be in direct opposition to intensive and usually unpredictable natural forces. Inlets may be stabilized by the construction of jetties or the operation of sand transfer facilities. Dredging performed in an inlet prior to its stabilization may prove to be inadvisable and uneconomical.

58. The State of North Carolina should not engage in dredging operations, either through purchase or rental of equipment or through contract with a dredging firm. If and when it appears advisable for the State to appropriate funds for dredging operations, such funds should be made available to the Corps of Engineers, an organization which for more than 125 years has made studies of North Carolina waterways, and which has acquired sufficient knowledge and experience to be able to perform the work more efficiently and economically than would be the case if the State performed the work or caused it to be performed through contract with a dredging firm.

59. The State should encourage and promote improvement of waterfront appearances in order to make the waterways more attractive to tourists and vocationists, and should provide advice and technical assistance in connection therewith.

60. The Department of Conservation and Development should take appropriate action to obtain the support of the National Rivers and Harbors Congress, the Chief of Engineers, and the North Carolina delegation in the Congress in obtaining authorizations of, and appropriations for, navigation improvements. Local interests should attend meetings of the National Rivers and Harbors Congress, and the Appropriations Committees of the Congress of the United States with a view to assisting the State and the North Carolina delegation in obtaining appropriations for authorized projects which have not been started and for projects under way which have not been completed.

61. Local interests should assist the Department of Conservation and Development in establishing in the Coastal Plain industries which will increase the tonnages handled at the ports and on whe waterways.

62. Local interests should, in order to advance construction of authorized projects which have not been completed, and completion of projects under way which are awaiting Federal appropriations therefor, give consideration to offering cash contributions to the Federal Government as tokens of their belief that the initiation or completion of construction is urgent and of their willingness to share the costs thereof. Local interests in other states have taken such action and have thereby obtained Federal financial assistance earlier than would otherwise have been the case. The accrued benefits in most instances have probably exceeded the amounts of the local participation.

FLOOD CONTROL

63. Flood control reduces damages to property, and danger and inconvenience to the people, located within the overflow limits of rivers, and is

accomplished by flood-control dams and retarding reservoirs, or by levees and floodwalls, or a combination of both of these methods. It has contingent benefits, including the minimizing of water shortages, reduction of the effects of depreciation of water quality by industrial and sanitary wastes, and, in some cases, prevention of salt water intrusion into tidal rivers.

64. The great increase in losses from floods, along with the development and growth of the State, is creating a demand for alleviation and prevention, by intelligent engineering works, of conditions causing floods.

65. Much can be done toward alleviation and prevention of damages occasioned by floods through construction of intelligent engineering works if supported by enlightened public opinion. The great increase of these damages with the development and growth of the State is creating a constant demand for such betterments. Unfortunately, it generally requires a specially disastrous flood to arouse the public and make it realize the need and value of flood protection.

66. Both upstream measures, including proper land-use practices and construction of storage or detention basins, and downstream measures, including channel improvement, bank protection, and flood-control dams, can be advantageously used to alleviate and prevent damages.

67. The Corps of Engineers have completed the clearing and snagging of the channel of the Tar River between Tarboro and Rocky Mount, the Goldsboro Flood Control Project, dikes in Bladen County along the Cape Fear River, clearing and snagging Trent River and New River (Onslow County), and the John H. Kerr Reservoir near Clarkesville, Virginia, which is preventing disastrous floods such as have occurred in the lower Roanoke River Basin in North Carolina. The Pasquotank River Flood Control Project, the Moores Ferry Reservoir (New River, Alleghany County, North Carolina, and Grayson County, Virginia), and reservoirs in the upper Yadkin River Basin near Wilkesboro and North Wilkesboro have been authorized and are awaiting appropriations. Eleven proposed flood-control projects, which may be of benefit to the State, are under investigation by the Corps of Engineers.

BEACH EROSION

68. The Department of Conservation and Development collected beach erosion data from 1927 until 1941, when the work was discontinued because of the exigencies of World War II. Collection of data was resumed in the summer of 1954. Most of the work performed in 1954 will be repeated because of damages to the beaches caused by Hurricane Hazel on October 15, 1954.

69. Sand fences are particularly effective as dune builders in those areas, such as Nags Head and Kitty Hawk, where dry sand is moved by wind action. They will not collect sand in the tidal flats, such as those at Oregon Inlet, where the sand is alternately exposed and covered by water during the rise and fall of the tide. After dunes have been artificially formed by sand fences, they should be stabilized by planting marsh grass in clumps about a foot apart over the whole area of the dune ridge.

70. It appears that continuation of repair of groins at the south end of Wrightsville Beach and periodic replacement of lost artificial fill, or construction of a revetment around the south end of the island, will be effective

in maintaining a satisfactory beach.

71. Shoaling in the Intracoastal Waterway has occurred as a result of the new inlet cut from Myrtle Sound to the Atlantic Ocean at the northern extension of Carolina Beach.

72. A groin system at Fort Fisher is required to arrest erosion and to prevent a possible break-through to the Cape Fear River at this point.

73. Costly buildings should not be erected in North Carolina near the Atlantic Ocean unless the owners take adequate measures to effect beach stabilization.

74. Areas such as the area between Kitty Hawk and Nags Head deserve more favorable consideration for beach recreation development than those having a long-time history of erosion, against which stabilization measures have not been effected.

75. Beach communities should take action to prevent the lowering of dune ridges and the cutting of gaps in the dunes. Where paths in dunes exist, they should be closed by sand fences. When the fences have been covered by wind-driven sand, the areas should be stabilized by planting grass thereon.

76. Studies of erosion of North Carolina beaches should be continued to serve as a guide in future planning of beach recreational facilities and as a basis to formulate more definite conclusions concerning the science of shore changes and processes.

77. The Beach Erosion Board assists the Chief of Engineers, Department of the Army, in discharging the responsibilities assigned to him by the Congress of the United States in connection with investigations and studies with a view to devising effective means of preventing erosion of shores. The American Shore and Beach Preservation Association brings together for cooperation and mutual helpfulness the many agencies, interests, and individuals concerned with the protection and proper utilization of the coasts, and shores of lakes and rivers, of the Nation, and fosters in all legitimate ways sound, far-sighted, and economic development and preservation of the coasts and shores which will aid in placing their benefits within the reach of the largest possible number of the people of the United States. The Department of Conservation and Development should continue its collaboration with the Beach Erosion Board and the American Shore and Beach Preservation Association.

78. The Federal Government will assist in the construction, but not the maintenance, of works for protection of the shores of publicly-owned property. The Federal contribution toward such construction shall not in any case exceed one-third of the cost. Federal participation in the construction of works for protecting privately-owned shores is not authorized.

79. No beach erosion study by the Chief of Engineers, in cooperation with agencies of States and territories, shall be made in any state which does not provide for cooperation with the agents of the United States and contribution to the project of 50 per cent of the estimated cost of the study.

80. In view of the importance of protection of North Carolina beaches, emphasized by the damages caused thereto by Hurricane Hazel on October 15, 1954,

it is believed that a qualified beach erosion engineer should be employed permanently by the Department of Conservation and Development and paid from funds appropriated biennially by the General Assembly.

WATER LAW

81. Water legislation should recognize two principles: (1) that any user may have the right of use, but that water as such in public wealth, and whoever does make use of it must release all that is left in a condition which will not prevent good uses while the water is in transit and (2) no use of water should create a monopoly. Legislation should secure the greatest return from all uses of water. Uses should have a position in proportion to their value to the community as a whole. It should be flexible and forward-looking enough to supply the legal basis for achieving these uses.

82. Water legislation is needed to resolve inevitable conflicts in storage and water rights and to provide a sound legal foundation on which to build a pattern of wise, just and efficient water-use.

83. Permits should be required for uses of water for all purposes instead of only use of water for irrigation, as is the case under the existing law of North Carolina.

84. Water legislation should prevent handicaps to efforts to provide better physical means to store surplus water during times of above-average rainfall for use during droughts, and efforts to decide whose claim to water is best and what share each user should get.

85. When water was plentiful for all, the old riparian doctrine was adequate. In the complex economy of today, when uses materially reduce the total supply, riparian law has been found by hard and costly experience to be inadequate in certain respects.

86. Water legislation should provide security of investments in water development and land.

CHAPTER XIX - - RECOMMENDATIONS

In view of the conclusions contained in Chapter XVIII, the following recommendations are made:

1. That, in order to prevent the occurence of more and more shortages of water, appropriate action be taken to check the misuse of water wealth and to adopt sound principles of conservation and proper use of water.

2. That effort be made to convince the people of North Carolina that water resources are not inexhaustible, and that there is an ever-increasing need for conservation of the State's water resources.

3. That action be taken to store water in times of abundance in order to provide for requirements in times of scarcity.

4. That it be borne in mind that the State's resources for domestic and municipal water supply must have first priority, and that the saving of water, the proper channeling of it, and the prevention of huge losses constitute a major problem of public interest and concern.

5. That action, presently in process to increase storage of water, both for general farm operations and for the farm homes, be expanded.

6. That appropriate action, which will protect owners of land on the banks of streams against the construction of dams or other damaging uses of water by owners of land above them, be taken.

7. That education, presently being provided to farmers with a view to preventing recurrence of mistakes which have been made in connection with purchases and uses of irrigation equipment, be expanded.

8. That suppliers and users of waters for industrial purposes make long-range plans, and effect at the appropriate time these plans, for the intelligent development, utilization, and conservation of local and regional water resources in line with established and anticipated needs.

9. That the importance of use of water for recreation be recognized and that appropriate provision therefor be made in the planning of flood-control, water-supply, and hydroelectric reservoirs.

10. That the scope of cooperative agreements between the State and the Federal Government, providing for stream-gaging operations, ground-water investigations, chemical analysis of water, and salt water intrusion studies, be expanded as need therefor develops and to the extent of available funds.

11. That adequate funds be provided for topographic mapping required for intelligent planning and development of water-resources projects and programs involving land and water utilization.

12. That the effective work of the State Stream Sanitation Committee, during the period of approximately four years which has elapsed since its creation, be recognized, and that its future operations be supported and encouraged.

13. That programs pertaining to proper land-use practices, including strip cropping, contour planting of row crops, terracing, reforestation, retention of water by grasslands, stabilizing and sediment control structures, and upstream floodwater-retarding structures, for the purposes of causing substantial reductions in floodwater and sediment damages, preserving fertility, and increasing infiltration rates to place more water in the soil to be available for plant use during dry periods, be continued and enlarged.

14. That the efforts of the Department of Conservation and Development, in collaboration with the office of the Chief of Engineers, Department of the Army, the National Rivers and Harbors Congress, the North Carolina delegation in the Congress of the United States, and local interests, to obtain authorizations of recommended flood control and navigation projects, and appro-

priations for authorized flood control and navigation projects, be continued with a view to more effective accomplishment in the future.

15. That appropriate action be taken to determine the respective rights of water-users.

16. That the State encourage and support the efforts of soil conservation districts to accomplish proper land-use practices and watershed projects under the provisions of Public Law 566, 83rd Congress, 2nd Session and subsequent legislation, when enacted, pertaining to such practices and projects.

17. That the State adopt a policy of non-support of performance of dredging in inlets which have not been stabilized.

18. That the State refrain from engagement in the dredging business either through purchase or rental of dredging equipment, or contract for performance of dredging, and that, upon appropriation of funds for dredging operations, such funds be made available to the Corps of Engineers for performance of the desired work.

19. That the State encourage and promote improvement of waterfront appearances, and provide advice and technical assistance in connection therewith.

20. That local interests assist the Department of Conservation and Development in establishing in the Coastal Plain industries which will increase the tonnages handled at the ports and on the waterways.

21. That local interests give consideration to offering cash contributions to the Federal Government as tokens of their belief that the initiation of authorized navigation projects, or completion of navigation projects underway, is urgent, and of their willingness to provide a reasonable share of the cost thereof.

22. That beach communities take appropriate action to prevent the lowering of dune ridges and the cutting of gaps in the dunes; to close, and prevent the opening of, paths in the dunes; to allow no building to be erected oceanward of the dune ridge; to require substantial buildings in the vicinity of strands to be placed on adequate foundations and properly anchored thereto; and to prevent the separation by storms of pier members from structures of which they constitute parts.

23. That the General Assembly provide funds for the full-time employment of a qualified beach erosion engineer.

24. That appropriate action be taken to provide a sound legal foundation for resolving inevitable conflicts in storage and water rights; building a pattern of wise, just, and efficient water-use; preventing handicaps to efforts to provide better physical means to store surplus water during times of above-average rainfall for use during drought, and efforts to decide whose claim to water is best and what each user should get; and providing security of investments in water development and land.